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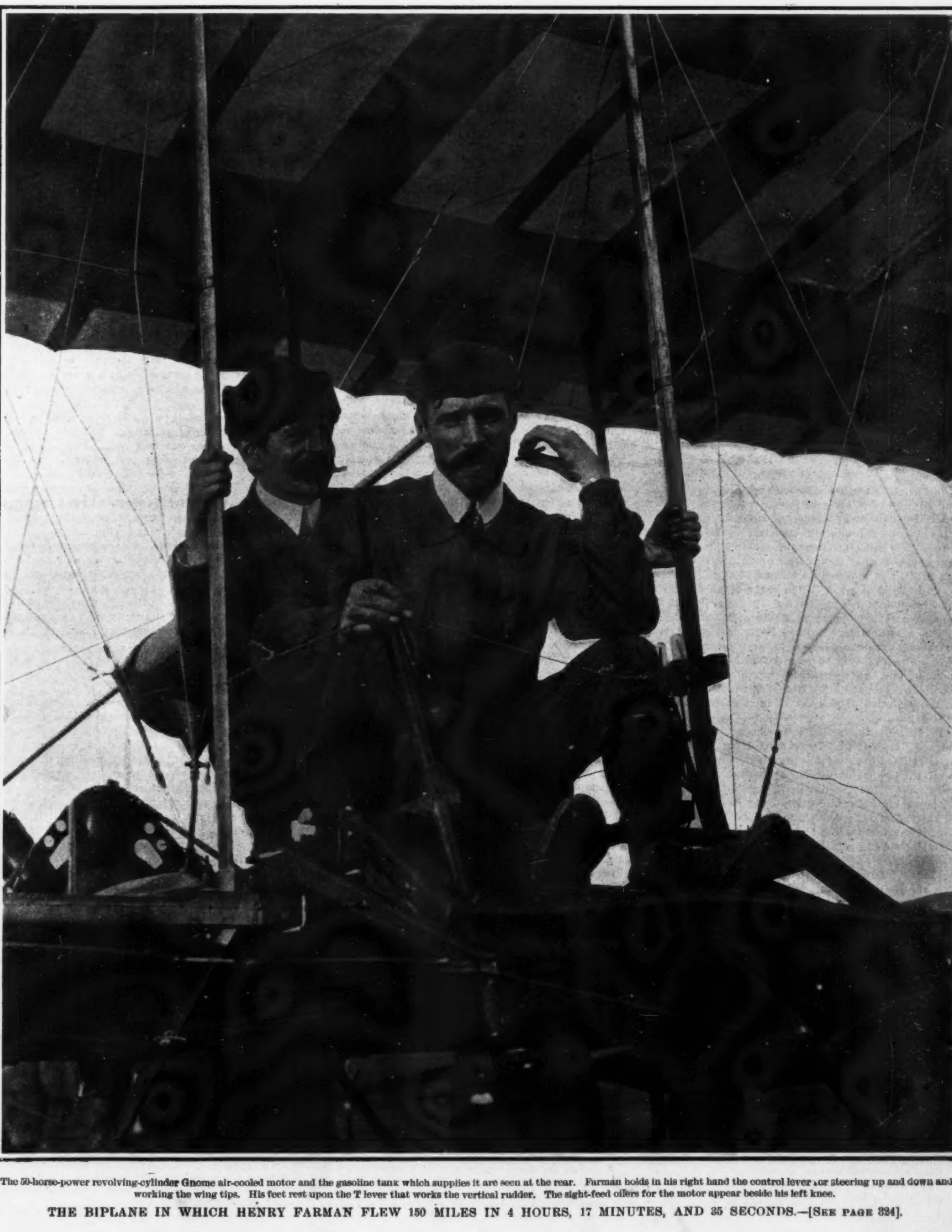


The 50-horse-power revolving-cylinder Gnome air-cooled motor and the gasoline tank which supplies it are seen at the rear. Farman holds in his right hand the control lever for steering up and down and working the wing tips. His feet rest upon the T lever that works the vertical rudder. The sight-feed oilers for the motor appear beside his left knee.

THE BIPLANE IN WHICH HENRY FARMAN FLEW 150 MILES IN 4 HOURS, 17 MINUTES, AND 35 SECONDS.—[See page 324].

BAKELITE, A NEW COMPOSITION OF MATTER.*

ITS SYNTHESIS, CONSTITUTION, AND USES.

BY L. H. BAEKELAND, SC.D.

SINCE many years it is known that formaldehyde may react upon phenolic bodies. That this reaction is not so very simple is shown by the fact that, according to conditions of operating or to modified quantities of reacting materials, very different results may be obtained; so that bodies very unlike in chemical and physical properties may be produced by starting from the same raw materials. Some of these so-called condensation products are soluble in water, other ones are crystalline, while some others are amorphous and resin-like. Then again, among the latter resinous products some are easily fusible and soluble in alcohol or similar solvents while other ones are totally insoluble in all solvents and infusible. This paper will deal with a product of the latter class.

The complexity of my subject compels me to make a brief historical outline which will allow us to form a clearer idea of the scope of my work and differentiate it from prior or contemporary attempts in subjects somewhat similar.

That phenols and aldehydes react upon each other was shown as far back as 1872 by Ad. Bayer and others.[2]

The substances obtained by the investigators were merely of theoretical interest and no attempt was made to utilize them commercially; furthermore their method of preparation was too expensive and too uncertain, and the properties of some of their resinous products were too undecided to suggest the possibility of utilizing them for technical purposes.

Until 1891 attempts at synthesis with formaldehyde were generally limited to the use of its chemical representatives, either methylal, methylen acetate, or methylen-haloid compounds.

With the advent of cheap commercial formaldehyde, Kleeberg[3] took up again this subject, using formaldehyde solution in conjunction with phenol and in presence of strong HCl. Under spontaneous heating he obtained a sticky paste which soon becomes a hard irregular mass. The latter is infusible and insoluble in all solvents and resists most chemical agents; boiling with alkalies, acids or solvent will merely extract small amounts of apparent impurities.

As Kleeberg could not crystallize this mass, nor purify it to constant composition, nor in fact do anything with it after it was once produced, he described his product in a few lines, dismissed the subject and made himself happy with the study of nicely crystalline substances as are obtained by the action of formaldehyde and polyphenols, gallic acid, etc.

The mass obtained after Kleeberg's method is a hard and irregular porous substance containing free acid which can only be removed with difficulty after grinding and boiling with water or alkaline solutions. The porosity of the mass is due, as we shall see later, to the evolution of gaseous products during the process of heating.

In 1899 Smith,[4] realizing probably that Kleeberg's method does not lend itself to molding homogeneous articles, tried to moderate the violent reaction by using a solvent like methyl-alcohol or amyl-alcohol in which he dissolves the reacting bodies as well as the condensing agent, muriatic acid. Even then the reaction is too violent if formaldehyde be used, so he does not use formaldehyde, but instead he takes expensive acetaldehyde and paraldehyde, or expensive polymers of formaldehyde. After the reaction, he slowly evaporates the mixtures and drives off the solvent at 100 deg. C. He thus obtains, by and by, a hardened mass in sheets or slabs which can be sawed, cut, or polished. In his German patent specification[5] he insists on the fact that in his process the methyl- or amyl-alcohol not only act as solvents but participate in the reaction, and he states that this is clearly shown by the color of the final product, which is dependent on the nature of the solvent he employs. He mentions that his drying requires from 12 to 30 hours; my own experience is that it takes several days to expel enough of the solvent; and even after several months there is still a very decided smell of slowly liberated solvent. During the act of drying I observed in every instance warping and irregular shrinking of the mass, which thereby becomes deformed and makes this method unfit for accurate molding.

In 1902 Luft[6] tried to overcome these difficulties in a somewhat similar way. Like Kleeberg he uses a mixture of formaldehyde, phenol and an acid; but recognizing the imperfections of the product and desiring to make of it a plastic that can be molded, he mixes the mass before hardening, with suitable solvents such as glycerine, alcohol, or camphor. He virtually does the same thing as Smith, with the difference, however, that he adds his solvent after the main reaction is partially over and uses his acid condensing agent in aqueous solution. His aim, as clearly expressed in his patent specifications, is to obtain a mass which remains "transparent and more or less plastic." After pouring his mixture in a suitable mold he dries at a temperature of about 50 deg. C. He too insists on the advantages of using solvents, and in his German patent (page 1, line 44) he states that from 2 to 10 per cent glycerine must remain in the mass; moreover, he arranges matters so as to retain in his mixture all the expensive camphor. The whole process of Luft looks clearly like an attempt to make a plastic similar to celluloid and to prepare it and to use it as the latter. The similarity becomes greater by the use of camphor and the same solvents as in the celluloid process.

I have prepared Luft's product; it is relatively brittle, very much less tough and flexible than celluloid; it does not melt if heated, although it softens decidedly; acetone swells it and suitable solvents can extract free camphor and glycerine from it.

And now we come to an attempt of another kind, namely, the formation of soluble synthetic resins, better known as shellac substitutes.

Blumer[7] boils a mixture of formaldehyde, phenols, and an oxyacid, preferably tartaric acid, and obtains a fusible, alcohol-soluble, resinous material, which he proposes as a shellac substitute. This substance is soluble in caustic soda lye; it can be melted repeatedly, and behaves like any soluble fusible natural resin. Blumer in his original English patent application puts great stress on the use of an oxyacid, and seems to think that the latter participates prominently in the reaction; he uses it in the proportion of one molecule of acid for two molecules of phenol and two molecules of formaldehyde.

Nathaniel Thurlow, working in my laboratory on the same subject, has conclusively shown several years ago that the identical material can be obtained by the use of minute amounts of inorganic acids; he has shown furthermore that equimolecular proportions are not necessary; in fact they are wrong and harmful if the reaction be carried on in such a way that no formaldehyde be lost; he showed also that in order to obtain a fusible soluble resin, an excess of phenol over equimolecular proportions must be used, unless some formaldehyde be lost in the reaction.

So as to avoid confusion, I ought to mention here that Blumer and Thurlow's resin is relatively very brittle, more so than shellac, and that no amount of heating alone changes it into an insoluble, infusible product.

As to the real chemical constitution of this interesting product which I have tried to establish by indirect synthesis, I shall read a paper on this subject at one of the next meetings of this society.

About a year later, Fayolle[8] tries to make gutta-percha substitutes by modifying Luft's method. He adds large amounts of glycerine to the sulphuric acid used as condensing agent, and obtains a mass that remains plastic and can be softened and kneaded whenever heat is applied. On trial this method gave me a brittle, unsatisfactory substance of which it is difficult, if not impossible, to wash away the free acid without removing at the same time much of the glycerine. In this relation, Luft's way of adding the glycerine after eliminating the acid seems more logical.[9]

Later[10] the same inventor modified his method by adding a considerable amount of pitch ("brai") and oil, thus trying to make another gutta-percha substitute which also softens when heated and remains plastic.

In 1905 Story [11] modifies all above methods in the following way: He discontinues the use of condensing agents and of added solvents; but he takes a decided excess of phenol, namely, 3 parts of 40 per cent formaldehyde and 5 parts of 95 per cent cresol or carbolic acid; by this fact the latter is present in excess of equimolecular proportions. He boils this mixture for 8 to 10 hours, then concentrates in an open vessel which drives off water and some formaldehyde, and which increases still more the excess of phenol; after the mixture has become viscous he pours it into suitable molds, cools down, and afterward hardens by slow drying below 100 deg. C., or as stated in his patent, at about 80 deg. C. His product is infusible and insoluble. But this method has some very serious drawbacks which I shall describe summarily and which Story himself recognized later.[12]

His process is necessarily slow. Leaving out of consideration his long preliminary boiling, the hardening process at temperatures below 100 deg. C. is really a drying process where the excess of phenol that provisionally has acted as a solvent is slowly expelled. This assertion I have been able to verify beyond doubt by my direct experiments where hardening was conducted in closed vessels at below 100 deg. C., and where I succeeded in collecting phenol with the eliminated water. The evaporation or drying process may proceed acceptably fast for thin layers, or thin plates, but for masses of a somewhat larger volume, it requires weeks and months; even then the maximum possible hardness or strength is not reached at such low temperatures. All this not merely involves much loss of time, but the long use of expensive molds, a very considerable item in manufacturing methods; furthermore, during the act of drying, the evaporation occurs quickest from the exposed surface, thus causing irregular contraction and intense stresses, the final result being misshapen molded objects, rents, or cracks.

Story states that if pure phenol be used the reaction proceeds very slowly; I should add that in that case the reaction does not take place, except very imperfectly, even after several days of continuous boiling. Even then in some of my own experiments made with pure commercial crystallized phenol and with commercial 40 per cent formaldehyde, I obtained products not of the insoluble type, but similar to the soluble fusible products of Blumer and Thurlow.

Taken in a broad sense, Story's process is very similar to Luft's with this difference, however, that he foregoes the use of an acid condensing agent, and instead of using a solvent like alcohol, glycerine, or camphor, he uses a better and cheaper one, namely, an excess of phenol. In further similarity with Luft and Smith's his method is, as he expresses himself in his patent text, a drying process.

Like Smith and Luft he is very careful to specify temperatures not exceeding 100 deg. C. for drying off his solvent.

Shortly after Story filed his patent DeLaire[13] obtained a French patent for making soluble and fusible resins either by condensing phenols and formaldehyde in presence of acids, in about the same way as Blumer or Thurlow, and then melting this product, or by dissolving phenol in caustic alkalies used in molecular proportions, then precipitating the aqueous solution with an acid and afterward resinifying the reprecipitated product by heating it until it melts. I should remind you that the French patent laws allow patents without any examination whatever as to novelty. And I should state also that DeLaire simply uses here the old and well-known processes of Lederer[14] and Manasse[15], which consist in making a phenol-alcohol by the action of formaldehyde on an aqueous solution of a phenolate and subsequent treatment with an acid.

It is a well-known fact that these phenol-alcohols, for instance saligenin, if heated alone or with an acid, will give partial anhydrides such as saliretin and homosaliretin,[16] $C_{14}H_{14}O_3$ or $C_6H_4(OH)CH_2OC_6H_4CH_2OH$,[17] fusible and soluble in alcohol, or caustic soda, and precipitable from the latter by the addition of chloride of sodium.

Trisaligenosaligenin, $C_{28}H_{26}O_5$ or $4C_7H_8O_2—3H_2O$,[18] and heptasaligenosaligenin, $C_{56}H_{50}O_9$ or $8C_7H_8O_2—7H_2O$,[19] are

[1] Paper read before the New York Section of the American Chemical Society on February 5th, 1909.

[2] Ber., 5, 1095; 10, 3004 and 3009; 25, 3477; 27, 2411.

[3] Annalen, 263, 283 (1891).

[4] Engl. Pat., Arthur Smith, 16247, August 9th, 1899.

[5] D. R. P. A. Smith, 112685, October 10th, 1899.

[6] D. R. P. Adolf Luft, 140552, April 29th, 1902; U. S. P. 735278.

[7] Engl. Pat., Louis Blumer, June 5th, 1902, No. 12880.

[8] French Pat., E. H. Fayolle, 335584, September 26th, 1903.

[9] See also addition patents to original French Pat. a d. Pat. 2414. February 8th, 1904, and 2485, February 18th, 1904. Fayolle.

[10] French Pat., E. H. Fayolle, 341013, March 7th, 1904.

[11] Engl. Pat., Henry Story, 8875, 1905.

[12] See his addition Patent, Belgium 210965, September 30th, 1908.

[13] French Pat., DeLaire 361539, June 8th, 1905.

[14] Journal Praktische Chemie [2], vol. 50, page 224.

[15] Ber., 1894, 2409-2411; D. R. P. Bayer, 85588; U. S. P., Manasse, 526786, 1894.

[16] Beilstein, Organ. Chemie, Vol. 2, 1896, page 1109.

[17] R. Piria, Ann. Chem., 48, 75; 56, 37; 81, 245; 96, 357. Moitessier, Jahresbericht, 1886, page 676.

[18] K. Kraut, Ann. Chem., 156, 123; Gerhardt, Ann. Chim. Phys. [3], 7, page 215.

[19] F. Beilstein and F. Seelheim, Ann. Chem., 117, page 83.

both higher anhydrides of similar resinous character, the first one obtained by the action of sulphuric acid on saligenin, the latter by the action of acetic anhydride.

The direct homologue of saliretin, which is methylsaliretin or homosaliretin, has properties similar to saliretin, melts at 200 deg. or 205 deg. C., and is less soluble.[20]

No wonder then if the English[21] and the German patents[22] of DeLaire vary considerably in text and claims from the French patent; the claims are reduced merely to a method consisting in resinifying phenol-alcohols by heating them under reduced pressure or vacuum. The resins of DeLaire are fusible, soluble products, having all the general properties of saliretin and homosaliretin.

In order to complete my enumeration of methods where alkalies are used, I ought to mention two processes which aim at products very different from those which we have in view. Speyer[23] produces an antiseptic which easily gives off CH_2O. For this purpose he uses naphthol or polyphenols like resorcin or pyrogallol and adds an excess of ammonia and of formaldehyde. This gives him an insoluble powder which easily liberates CH_2O and NH_3. It is a well-known fact that ammonia reacts on formaldehyde and produces hexamethylentetramin, $C_6H_{12}N_4$,[24] which easily acts upon acids and forms again CH_2O, NH_3 and methylamin.[25]

Two recent patents relate directly to the manufacture of soluble fusible resins. One of Farbenfabriken Fried. Bayer = Co.[26] uses orthocresol so as to obtain an odorless shellac substitute.

The other issued to Grognot[27] also for a shellac substitute, adds glycerine first, then after the reaction is over distills the solvent off.

After I had filed my own patent claims in the United States, which gave me International Convention privileges, Helm[28] described, after me, amines or ammonium salts as condensing agents for the manufacture of synthetic resins with phenols and formaldehyde. He does not clearly indicate the chemical or physical properties of his resins. He furthermore makes the rather ambiguous statement that ammonium nitrate can be used as well as aniline. I have shown (see below) that in the case of ammonium nitrate the end-product may be a fusible soluble resin, while in the case where aniline is used I obtain finally an insoluble infusible resin.

It is true that Helm uses large amounts of aniline and nitrate of ammonium; his indicated proportions are very close to molecular proportions, and this undoubtedly has, as I will show later, a great influence on the nature of the resulting products.

Knoll,[29] who also applied for patents after the filing date of my United States patents, uses sodium sulphite or neutral, or acid or alkaline salts as condensing agents; disregarding again the fact established by me, that according to whether an acid, a base, an acid salt, or an alkaline salt be used, the resinous products may be totally different.

This will close my review of the work done by others, and I shall begin the description of my own work by outlining certain facts, most of which seem to be unknown to others, or if they were known, their importance seems to have escaped attention. Of these facts I have made the foundation of my technical processes.

As stated before, the condensation of phenols with formaldehyde can be made to give, according to conditions and proportions, two entirely different classes of resinous products. The first class includes the products of the type of Blumer, DeLaire, Thurlow, etc. These products are soluble in alcohol, acetone or similar solvents, and in alkaline hydroxides. Heating simply melts them and they resolidify after cooling. Melting and cooling can be repeated indefinitely, but further heating will not transform them into products of the second class. They are generally called "shellac substitutes," because they have some of the general physical properties of shellac.

The second class includes the products of Kleeberg, Smith, Luft, Story, Knoll, as well as my own product, in so far only as their general properties are concerned; but each one of them may be characterized by very distinct specific properties which have a considerable bearing on any technical applications. Broadly speaking, this second class can be described as infusible resinous substances, derived from phenols with aldehydes; some of them are more or less attacked by acetone, by caustic alkalies or undergo softening by application of heat. At least one of them is unattacked by acetone and does not soften even if heated at relatively high temperatures. None of them can be re-transformed into products of the first class even if heated with phenol.

These insoluble infusible substances can be produced directly in one operation by the action of formaldehyde on phenols under suitable conditions, for instance the process of Kleeberg (see above). Or they may be produced in two phases (see Luft and Story above), the first phase consisting of an incomplete reaction giving a viscous product that is soluble in alcohols, glycerine, camphor, or phenol, and which on further heating or after driving off the solvent may gradually change into an infusible product.

In order to be able to stop at the first phase, the condensing agents may either be omitted (see Story above) or they may be used moderately (see Luft above) or they may be diluted with suitable solvents, for instance methyl- and amyl-alcohol (see Smith above) or with glycerine (see Fayolle above).

In all these processes there is a further treatment by which the solvent is driven off during a drying process. For example, in the process of Smith or Luft, alcohol or glycerine is thus expelled partially; and in Story's process the excess of phenol is driven off in the same way by slow drying under 100 deg. C. In all these drying processes some of the solvent is left, either purposely, so as to insure flexibility or plasticity, or it is left involuntarily, because at temperatures of 100 deg. C. or below it is impossible to expel the totality of these solvents, part of which are stubbornly retained by the mass.

If I except the processes of Blumer, Thurlow, or DeLaire, and generally those which have in view fusible and soluble resins, in all above-mentioned patent specifications, temperatures of 100 deg. C. or much below are insisted upon.

And yet I have convinced myself by often repeated experiments that temperatures above 100 deg. C. and considerably above 100 deg. C. are best suited or indispensable for the complete and rapid transformation into a final insoluble, infusible product of exceptionally desirable qualities. If this be so, why have my predecessors not used temperatures above 100 deg. C.?

Why do some of them recommend temperatures as low as 80 deg. C. (Story) and even 50 deg. C. (Luft)? Why do they prefer to make this final hardening a long and slow operation which does not give the best, the hardest, the most resisting product? (See confirmation of my statement by Story in Belgian addition patent 210,965, September 30th, 1908.)

For the simple reason that if their initial mass be heated at too high a temperature it gives off gaseous products, mainly composed of formaldehyde; this produces bubbles in the mass, makes it spongy, porous, and unfit for commercial use.

More direct experiments have proved to me that during the first stages of the process, we have to deal with a phenomenon that has all the characteristics of chemical dissociation with liberation of CH_2O.

If the initial mass be heated at temperatures above 100 deg. C. the tension of this gas becomes very pronounced. At 100 deg. C. the tension may become as high as 1 kilogramme per square centimeter (above atmospheric pressure), but this tension subsides as soon as the final product is formed.

I shall explain later how I have utilized this knowledge to good advantage, and how I counteract this dissociation simply by exercising a compensating external pressure.

In the historical part of my paper reference has repeatedly been made to the use of condensing agents. We have seen how Kleeberg, Smith, Luft, Fayolle, Blumer, and Thurlow used acid condensing agents. Others, like Speyer, Hentsche, Lederer, Manasse, DeLaire, use alkalies, but every time in relatively large proportions—practically one molecule or over; but the products thus obtained are of a nature very different from the substance I am about to describe.

Story, on the other hand, adds no condensing agents whatever. True, he is able, with commercial impure carbolic acid, to obtain a reaction after about 8 to 10 hours' boiling, and this heating process has then to be supplemented by much longer drying. But if his process be carried out with pure or crystallized phenol, it takes many days of continuous boiling before a reaction sets in; even then the product obtained is of a dubious character hovering between a resin of class one (fusible and soluble) and a resin of class two (infusible and insoluble). It is more likely to be a fusible and soluble resin if for some reason or another the process has been carried out with an excess of phenol or if, some way or another, too much CH_2O has escaped in the after concentration. For instance, by following his description and boiling for five days in a return condenser a mixture of 50 grains pure crystalline phenol and 30 grains 40 per cent commercial formaldehyde, then concentrating in an open dish, I obtained the fusible soluble resin of Blumer or Thurlow which on further heating remains fusible and does not change into the insoluble infusible product as described by Story. I obtain the same result if the boiling be carried on in presence of a small amount of any acid, any acid salt, or any salt which on hydrolyzing may split, so as to give a preponderant acid reaction. This effect is shown by salts of mineral acids and heavy metals; it is shown even with ammonium chloride, and on acting upon formaldehydes liberates free hydrochloric acid.[30]

On the other hand, if I use an alkaline salt or a salt which on hydrolyzing splits into a weak acid and a strong base, as for instance sodium acetate, I obtain under the same circumstances a resin of the insoluble, infusible variety, even if to some extent a slight excess of phenol has been used, showing conclusively that within certain limits the amount of phenol does not change the general character of the reaction. All that may happen in that case is that the final product is rendered impure by some excess of phenol which can be driven off afterward by a drying process similar to that of Story.

I have obtained similar results with many other alkaline salts, as for instance ammonium carbonate, sodium carbonate, potassium carbonate, sodium bicarbonate, potassium bicarbonate, trisodium phosphate, borax, potassium cyanide, sodium silicate, soap, etc.

In the same way I have used sodium sulphite, which on acting on CH_2O liberates sodium hydroxide according to following reaction:

$CH_2O + SO_3Na_2 + H_2O = CH_2(OH)SO_3Na + NaOH.$

I might say that a similar effect is obtained from all substances which can act directly or indirectly as bases.

In other terms, the quality as well as the quantity of condensing agent has an enormous influence on the nature of the final products.

For the manufacture of insoluble, infusible, condensation products of formaldehyde and phenol, bases used in moderate amounts have very decided advantages. They accelerate the reaction without degenerating same into a violent and irregular process. The relatively small amount of base which may remain present in the finished product, either in combined or uncombined form, does not involve the same objectionable features for its technical uses as the presence of free acid.

Furthermore, for some reason or another acid condensing agents seem to favor the formation of soluble and fusible resins, while for some other reason, bases seem to favor the formation of insoluble, infusible resins.

Moreover, by the use of small amounts of bases, I have succeeded in preparing a solid initial condensation product, the properties of which simplify enormously all molding operations, as we shall see later.

(To be continued.)

[20] C. Schotten, Berichte, 1878, page 784.
[21] Engl. Pat., DeLaire, 15517, 1905.
[22] D. R. P., De Laire, 189262, July 19th, 1905.
[23] D. R. P., Arthur Speyer, 99570, November 2nd, 1897.
[24] Wohl, Ber., 19, 1892; Tollens, Ber., 17, 653.
[25] See also Moschatos and Tollens, Ann. der Chemie, 272, 280.
[26] D. R. P., Farbenfabriken vorm. Friedr. Bayer & Co., 201,261; April 16th, 1907.
[27] L. Grognot, U. S. P. 391436, 1908.
[28] Engl. Pat., Louis Helm, 25216, November 13th, 1907.
[29] Engl. Pat., Knoll & Co., 28009, December 19th, 1907; Swiss Pat., Ditto, 40994, December 7th, 1907.
[30] See Gambier, Brochet, Compt. rend., 120, 557.

HARVARD HOUSE, STRATFORD-ON-AVON.

HARVARD HOUSE, formerly known as "the Ancient House," has been presented to America and Harvard University by Mr. Edward Morris, of Chicago. The house, on whose front is the date "1596," has been reinstated and returned as far as is now possible to its pristine appearance. It was built for Thomas Rogers, alderman, whose daughter Katharine was married in Holy Trinity Church, Stratford-on-Avon, on April 8th, 1605, to Robert Harvard ("Harwod"), of High Street, Southwark, a butcher, and vestryman of St. Saviour's, she being his second wife. Of six children, issue of that marriage, four, with their father, died of the plague. The widow married again, and her son, John Harvard, was admitted to Emmanuel College, Cambridge, on April 17th, 1628. Nine years subsequently he, with other Puritans, went to New England. He died about twelve months after his arrival there; he bequeathed his library and a capital sum of £800 toward the endowment of a college, which has since developed into the university which bears his name. His mother and brother Thomas had left him a fairly good fortune, largely derived from the Queen's Head Tavern in Borough High Street. Her early home in Stratford-on-Avon contains an upper room, paneled in oak, and a Tudor mantel beading of plaster; in the passage which leads to the room are hung, in frames, a specimen, taken from the house, of the true wattle and dab work *temp.* Elizabeth, and a specimen of similar work as executed in our own time. It is a single-gabled half-timbered house, having three floors; on the elaborately carved front are roses, fleur-de-lys, and the bull and bear badges of the houses of Neville and Beauchamp. The date is between the initials, "T. R." and "A.R.," of Thomas, and his wife Alice Rogers.

THE FARMAN BIPLANE.

FULL DETAILS OF THE AEROPLANE WHICH HOLDS THE ENDURANCE RECORD.

One of the most successful pioneers in the practical side of aviation—winner of the historic Deutsch-Archdeacon prize by the accomplishment of the first circular kilometer and hero of the first cross-country flight—Henry Farman, has only latterly taken up the design and construction of the machines which bear his name. In his early work he used a Voisin flyer, and throughout the many succeeding experiments, in which one modification or another was made in respect to detail, the machine still retained most of what are, after all, the essential characteristics of the Voisin type.

The Farman flyer of to-day is a biplane; it has a biplane tail, carried on a rearwardly projecting outrigger, and it has a horizontal rudder in front. Where the Farman design differs materially from the Voisin system, however, is that the machine is totally devoid of vertical panels, either between the main planes or the supporting members of the tail. There is, of course, a rudder, or to be more precise, two rudders, which work in unison, but there is no prow, not even so much as exists on the Voisin flyer, where the covering in of the horizontal rudder outrigger serves this purpose to a certain extent.

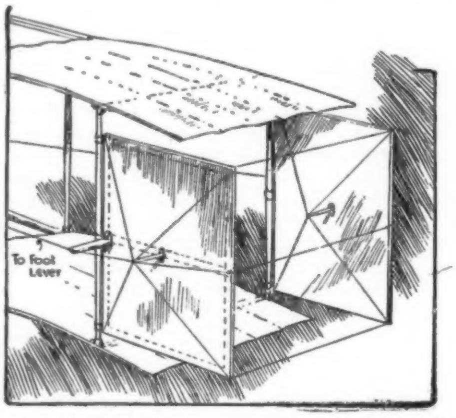
One very natural consequence of the absence of this vertical surfacing in the Farman machine is that it has a much lighter appearance, for there is nothing so well calculated to make a flyer look heavy as to box it in with side curtains. Another important feature of the Farman flyer, and one which originated on this machine, is the combination wheel-and-ski chassis. Being designed for launching by running along the ground, wheels are essential in the construction, but Mr. Farman was one of the first to appreciate the advantages of the ski on the Wright machine when it came to landing after a flight. A suspension which is in every way satisfactory for running about over smooth ground, preparatory to the start, is by no means necessarily adequate to meet the very severe shocks which are apt to be associated with descents on ground which has not exactly been chosen for the purpose. Here the advantages of skis assert themselves, the extent of their tread and of their strength to resist impact being particularly valuable under such circumstances.

THE MAIN PLANES.

The main planes have a span of 32 feet 6 inches, and measure 6 feet 4 inches on the chord; their aspect ratio is thus 5.1. The framework of the planes consists of two parallel transverse main spars, which pass from one extremity of the span to the other and lie parallel about 4 feet 9 inches apart. Across these spars are fastened curved ribs which overlap the rear spar by a distance of 1 foot 7 inches. The ribs are flush with the front spar which forms the leading edge of the plane.

The planes are single-surfaced with ordinary fine canvas, but the spars and the ribs are nevertheless inclosed in pockets of the same material. This is done in order to avoid sharp angles. The strips of fabric forming pockets for the ribs are sewn on to the upper surface. The pocket for the front spar is formed by turning back the main sheet of fabric, the edge of which is then stuck down on to the under surface. The pocket for the rear spar is formed by similarly attaching another strip of fabric to the under surface of the plane.

That part of the plane formed by the projection of the ribs beyond the rear spar constitutes a flexible trailing edge. It is not, however, continuous either in the top or in the bottom plane, owing to the provision of hinged balancing flaps and the necessity for accommodating the propeller. The hinged balancing planes are constituted by those portions of the trailing edge lying between the last pair of main struts at each end of the span. The accommodation of the propeller involves the cutting away of the trailing edge of the lower plane only between the main spars of the outrigger frame.



Sketch of the tail, showing the arrangement of the double rudder and the method of bracing the rudder.

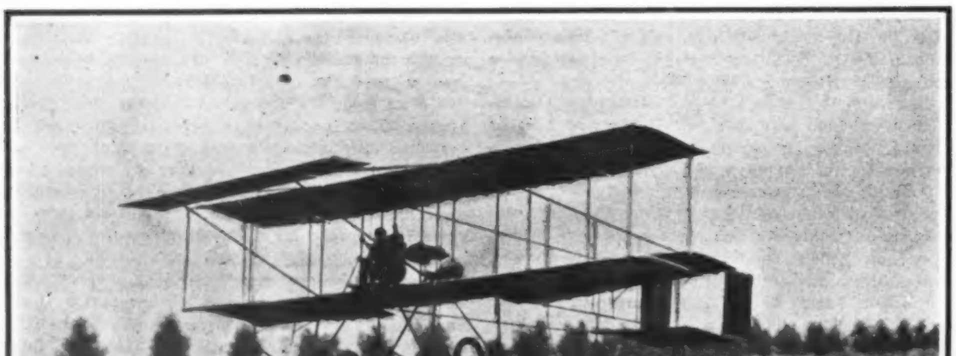
The main planes are separated by vertical ash struts, 6 feet 4 inches in height. The section of the struts forms a pointed oval. Diagonal wire ties crossing between the extremities of the struts brace the whole structure into a lattice girder.

THE FRAMEWORK.

In addition to the framework of the main planes, the complete machine includes two outriggers for the horizontal rudder and tail respectively, and a chassis for the support of the machine upon the ground. All of these members are constructed of timber and wire, ash being the principal wood used.

The tail outrigger is built up of four longitudinal ash spars, having a rectangular section. These are braced by vertical ash struts set in flanged aluminium sockets, and lugs attached to these sockets afford an anchorage for the adjustable diagonal tie-wires. There are no transverse struts between the spars, except those formed by the transverse spars of the main decks and tail. It will be noticed on reference to the drawing of this machine, that the longitudinal spars in the tail outrigger converge as they recede from the main decks.

The front outrigger forms, in elevation, an isosceles triangle with its apex pointing forward and upward. Each pair of converging spars is braced by a single vertical member and a pair of diagonal wires. The transverse bracing between the two pairs of struts forming the complete outrigger is constituted by the bar on which the horizontal rudder hinges.

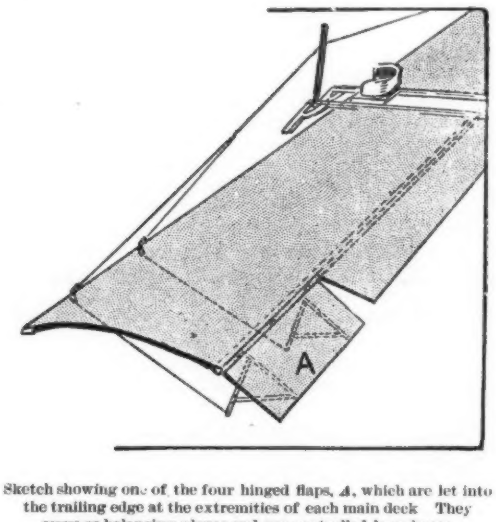


THE BIPLANE CARRYING A LADY PASSENGER AND 2 0 POUNDS OF BALLAST IN BAGS ON THE SKIS.

THE FARMAN BIPLANE IN FLIGHT.

The chassis frame is formed by two longitudinal skis, attached by six struts to the main frame of the flyer, as shown in our drawing; diagonal wires are used to complete the bracing as in other parts of the framework. The most interesting detail in the construction of the chassis is the method of mounting the wheels on the ski. They are carried by an axle which is strapped at its center to the ski by an arrangement of rubber bands, as shown in an accompanying sketch. Radius rods diverge from the ski to opposite ends of the axle in order to prevent slewing when one wheel strikes an obstacle, but as each radius-rod is separately hinged the axle can tilt as much as is required. When the elastic spring has been stretched to its permissible limit, the ski comes in contact with the ground, and takes the load direct.

Another frame member which is of particular importance, although eminently simple in the Farman flyer, is that which supports the engine and the pilot's seat. It is shown separately in an accompanying sketch, and consists in the main of two wood spars and a simple pressed-steel bracket. The spars lie fore and aft across the main-frame spars, to which they are clamped by U-bolts in order to avoid drilling the wood. A foot-rest, and a light seat for the pilot, are fastened direct to these spars at one end, while a pressed steel bracket for the support of the engine is attached at the other extremity. The bracket itself is of quite unusual shape, since its purpose is to provide a support for the stationary crank-shaft of the Gnome rotary engine. Its shape and position are sufficiently well illustrated by the sketch on the next page to need no further reference.



Sketch showing one of the four hinged flaps, *A*, which are let into the trailing edge at the extremities of each main deck. They serve as balancing planes and are controlled by a lever. Normally they are free to adjust themselves to the air stream lines.

SUPPLEMENTARY SURFACES.

The horizontal and vertical rudders, tail, and balancing planes comprise the supplementary surfaces of this biplane. The first is a monoplane constructed in three sections, in order to clear the outrigger which supports it, its span being greater than the distance between the main spars of that member. The leading edge of this rudder has been made continuous throughout the span, which is 15 feet in length. The tail is a biplane of approximately 7 feet span. Its surfaces are constructed like the main ones, and are similarly covered. The rudder is in duplicate, the two vertical planes constituting this member work in unison. They are hinged to the rear struts of the tail, and project some little distance beyond the trailing edge of that member. Their bracing, which is an interesting constructional detail, is well illustrated by an accompanying sketch. The balancing planes are the hinged portions of the main decks, to which reference has already been made. They are so mounted that they are free to adjust themselves to any natural position, and in flight would lie in the air stream line.

CONTROL.

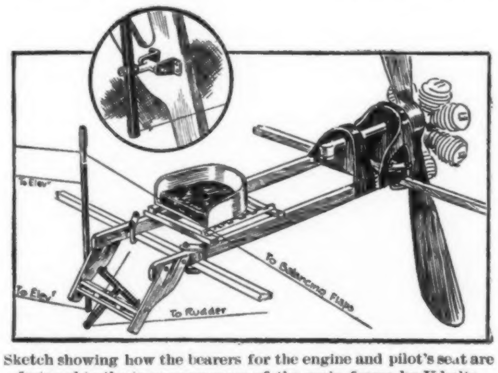
Situated at the driver's right hand, is a universally-pivoted lever, to which four wires are attached. Two operate the horizontal rudder, while the other two control the balancing flaps which form a portion of the trailing edge of the main planes, as already described. A to-and-fro motion of the lever controls the horizontal rudder, a backward movement tilting the leading edge for ascent, and *vice versa*.

Sideways motion of the lever works the balancing flaps, the connections being such that when the lever is moved to the pilot's right the flaps on the pilot's left are deflected downward, thus causing that end of the plane to be raised upward by the increased air-pressure which results from the movement. This maneuver also increases the resistance on that side of the machine, and in order to obtain the increased lifting effect required it is essential that the velocity at which that end of the plane travels through the air should be maintained; otherwise the increased angle of incidence will not have the desired effect, but will only serve to slew the machine from its proper course. The desired path is maintained by operating the rudders, which are controlled by wires attached to a pivoted foot-rest. Pressing with the right foot sets the rudder so that the machine steers to the pilot's right, a maneuver which would be used to counteract the slewing effect of depressing the left-hand balancing-flaps.

It will be observed that the connections have been designed to accommodate as far as possible what might be expected to be the natural actions of a pilot in emergency. If the machine cants so that the extremity on the left of the pilot is depressed, the pilot would naturally try to correct this by leaning over to the right, and in so doing he would automatically move the balancing-lever in that direction, and would probably also automatically press harder upon the right-hand end of the foot-rest. Both actions are those which it is intended should be performed as a means of righting the machine in the case indicated.

ENGINE AND PROPELLER.

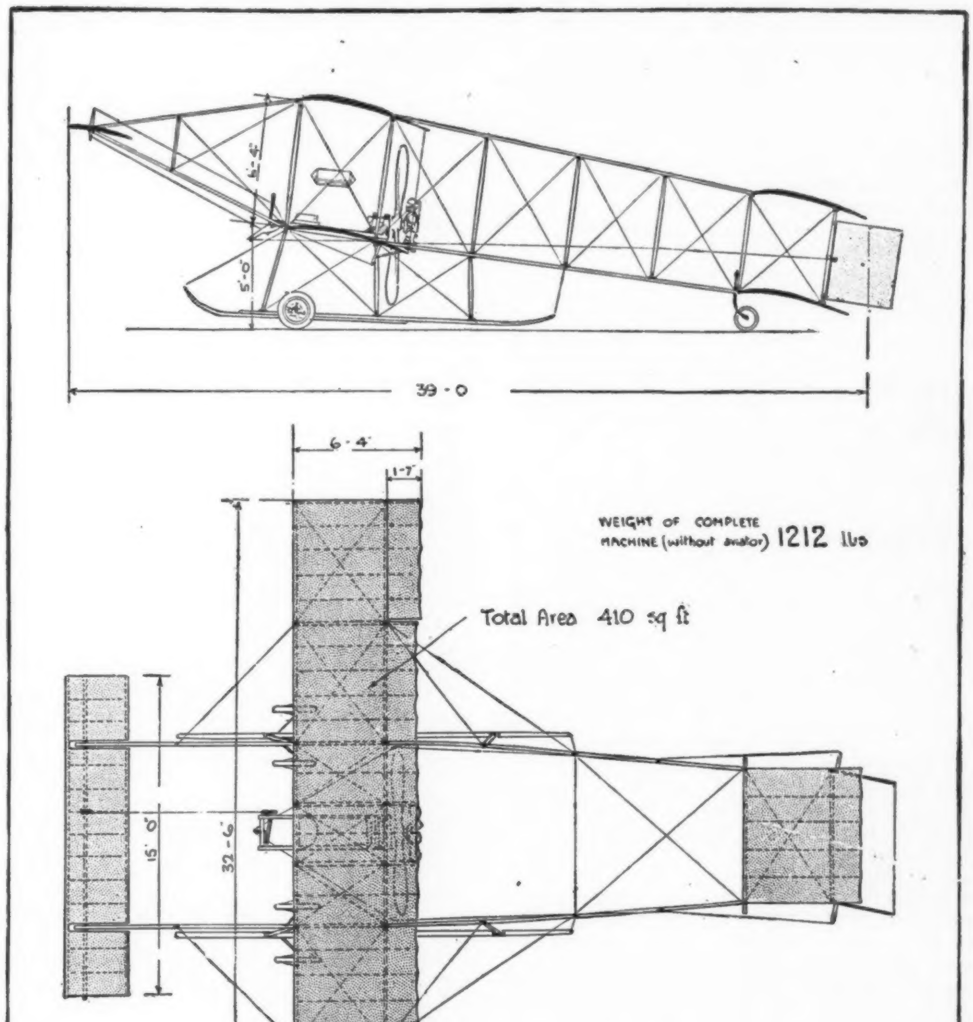
The engine at present fitted to the Farman flyer is a 7-cylinder Gnome rotary motor. A peculiarity in the arrangement of this engine is that it is situated behind the propeller. The engine itself is of the radial type, and has its cylinders and the crank-chamber constructed entirely of steel. The cylinders are air-cooled, and



Sketch showing how the bearers for the engine and pilot's seat are fastened to the transverse spars of the main frame by U bolts. The inset sketch shows the universal attachment of the control-lever to the side of the foot-rest.

have the exhaust valves situated in the center of the heads. The inlet valves are in the piston heads, the mixture being admitted through the hollow stationary crank-shaft. One of the principal problems in the development of this engine has been the balancing of the valves against the disturbing influence of centrifugal force, a difficulty which seems to have been satisfactorily surmounted, as the engine is apparently being used with success. The rotation of the cylinders affords, we are led to believe, a satisfactory solution of the air-cooling problem.

The propeller is made of wood, and has been built by Chauviere, whose workmanship invariably shows great care and high finish. The diameter is 8 feet 6 inches, and it has two blades.—Flight.



SIDE ELEVATION AND PLAN OF FARMAN'S 1909 BIPLANE.

HENRY FARMAN'S LATEST AEROPLANE.

VISION AMONG PLANTS.

By G. LOUCHEUX.

THE German botanist Haberlandt discovered in the epidermis of the leaves of certain plants vast numbers of very small cells, of the form of a double convex or plano-convex lens, which were filled with a transparent liquid. He assumed that these microscopic cells constituted a complex organ of vision which enabled the plants to distinguish between day and night and to place their leaves in the most advantageous position relatively to the sun's rays.

At the last meeting of the British Association for the Advancement of Science, Mr. Harold Wager presented a paper on the same subject. A translation of this paper has inspired M. Cunisset-Carnot, of the Paris Temps, to set forth in great detail the reasons, of a poetic nature, which lead him to believe in the existence of a sense of vision in plants. I will here state the reasons, of a scientific nature, which lead me to the opposite opinion.

According to M. Cunisset-Carnot, plants live in order to love. Their beauty is a sexual lure which they assume at the season of reproduction for the purpose of mutual attraction. This is very poetic, but I cannot see that plants need to attract each other in order to perpetuate their species. As a matter of fact, the most beautiful flowers belong to the class known as perfect, or hermaphrodite, both male and female organs being included in the same blossom. Here, surely, there is no need of mutual attraction, and very curiously, those plants in which the need of mutual attraction would appear to be greatest, namely, the diœcious plants, in which the male and female flowers are borne on different roots, have the least showy flowers. The willow, hemp, and mercury are familiar examples. Yet these plants multiply more than sufficiently, as the farmer whose meadows are infested with mercury will attest.

No! The beauty of flowers was not created for flowers, nor yet for us, for flowers existed long before men. For whom or what it was created we do not know.

If plants, for the reasons alleged, need organs of vision, they have an equal need of organs of hearing, touch, and smell, to enable them to perceive their mutual contacts, the rustling of leaves, and the perfume of flowers. These phenomena, however, do not exist for plants, which do not need them and do not perceive them, or perceive them by some mechanism unknown to us and for purely vegetative purposes. I do not deny that plants may possess organs of sense, but organs of the character of those which we possess are not necessary to plants. Even if a botanist should discover in plants new elements which appear to be the seat of some function hitherto unknown in the vegetable world and apparently sensorial, it would be impossible to specify the kind of impression which corresponds to that function, unless we could read the mind of the plant.

Our methods of investigation, in this as in other fields, cannot go beyond the observed phenomenon. In plants this phenomenon is almost always a chemical reaction, directly connected with nutrition. Practically all our knowledge of vegetable physiology is confined to this one essential function.

It is impossible for us to lift the veil which hides the sensibility of plants. Such a sensibility certainly exists, but its nature is chemical (heliotropism) or mechanical (movements of the sensitive plant). The sensation of pleasure or pain and the utilitarian purpose will always remain impenetrable mysteries.

Some have thought that the phenomena of heliotropism, or the turning of plants toward the light, require the existence of a rudimentary sense of vision, and that the object of the movement is the stimulation of the chlorophyl function. But it is not necessary to see light in order to be affected by it. Many chemical reactions take place without any conscious sensation on the part of the reacting substances. The function of chlorophyl may be such a reaction, and as it is especially dependent upon the ultra-violet rays which are incapable of affecting human eyes at least, the necessity for the existence of visual organs in plants is not apparent.

To regard plants as we regard human beings and to impose upon them all our sensorial needs is to commit a colossal error. The vegetable world is not our world; its objects and moving forces are not the same as ours; its intimate physiology is unknown to us. If plants possess organs of sense we know nothing of those organs and cannot discover them by our methods of investigation, and we are not justified in inferring that vision is useful to plants because it is useful to us.

I see only two ways of solving this unsolvable problem of the possession of sense organs by plants—either to awaken Flora and Pomona, the Fauns and the Dryads, from their long sleep and ask them what they think about it, or to wait until the plants themselves should deign to describe their impressions of the world about them in a new "language of flowers."—Cosmos.

In sinking a reinforced concrete caisson for a railway bridge near Gouda, Holland, the difficulties of keeping it vertical were overcome by the use of scaffolding from which the caisson was suspended from pulley blocks and steel ropes, each sustaining 100 tons. Dynamometers indicated the pull on each rope, thus showing irregularities in the soil.

THE MEASUREMENT OF HUMIDITY.*

THE INSTRUMENTS AND METHODS EMPLOYED.

BY SAMUEL K. PATTESON.

The question of the amount of moisture present in the atmosphere, its variation under different conditions of temperature and pressure, and its effect upon the efficiency of various engineering processes is one that is daily becoming more important to a constantly increasing number of engineers in a considerable variety of engineering developments. Thus it is known to-day that the moisture in the atmosphere affects unfavorably the action of almost every engineering device in which the atmosphere enters as a factor in its operation or design. The gas engine is affected very greatly in its action by the presence of moisture in variable amounts in the atmosphere, and in special developments of this type, such as the automobile engine, where the control of the charge is often inadequate and the load variable, the effect is often sufficient to temporarily swamp the engine. The same effect is also present in small marine engines with even more pronounced significance, and its effect is also present in all internal-combustion motor installations. Again, cooling towers depend for their efficient action almost entirely upon the amount of moisture present in the atmosphere, and under some conditions of great humidity their effective action is often almost completely stopped. The presence of moisture in the blast in iron furnace operation has long been known to be the chief variable quantity in its effect on the character and uniformity of the product, and only recently have satisfactory devices been constructed for the efficient elimination of the moisture in such cases. Again, the further development along this line in its effect on the character of the blast in Bessemer converter operations is such that possibly its utilization in this process will put the latter on an efficient basis where it can compete again with the open-hearth process. In air compression, as well, the presence of moisture in the air is well understood, and its limiting effect on efficiency can be greatly diminished by proper study and prevention of this phenomenon. These developments represent a comparatively few of the processes in which the presence of moisture in the air affects the efficiency of the operation, but they are essentially the more important classes and give a fair idea of the importance of this factor in engineering progress.

The fact that water vapor exists in the air has been known for a long time, and very good and satisfactory data have been at hand in regard to its amount under all conditions, and the methods of its measurement or determination are quite simple and readily available under all conditions. The problem itself from a physical or engineering viewpoint is essentially a single development of the broader one involved in the mixture of two or more vapors or gases or gases and vapors, and the laws governing their relative proportions under variable conditions of temperature and pressures are fairly well understood, although this development is one in physical science which is undergoing rapid progress to-day. The basic conditions or laws which govern all these relations are primarily the fundamental laws of gases and vapors. Thus Boyle's law holds for a gas independent of the presence of some other gas or vapor. In an equal sense Charles's law, showing relation between pressure, volume, and temperature of the gas, is equally true, independent of the presence or intimate mixture of some other gas or vapor in the one under measurement. Dalton's law is the particular one that applies in these conditions, and, stated briefly, consists in the fact that all gases or vapors exist in conjunction with each other according to exactly the same laws that would hold if the others were not present. Thus, water vapor occupies space filled with air in precisely the manner that water vapor would tend to occupy space or vacuum if the air were not present. The ordinary atmospheric pressure of 14.7 pounds to the square inch is, therefore, according to this law, a combination pressure, due to the pressure of the atmosphere alone and the pressure of the water vapor present. The water vapor exists in quantities in this air dependent upon the temperature alone, and varies with it, and also with conditions which affect its degree of saturation. Thus, according to Dalton's law, if a cubic foot of dry air is taken, it will exert a definite pressure of, say, 14 pounds to the square inch. If a drop or two of water is injected into this, under normal conditions, the pressure will immediately rise from $\frac{1}{2}$ to 1 pound to the square inch, and the pressure of the mixture will then be, approximately, 15 pounds, as recorded on an absolute pressure gage. If a drop or two of alcohol is then injected into the mixture, the vapor of this liquid will tend to occupy the space in precisely the manner the water vapor has done and just as though the others were not present. Under these conditions the pressure will rise again from $\frac{1}{4}$ to $\frac{3}{4}$ of a pound, or a variable amount dependent upon the nature of the vapor and the temperature. As far as known, pressure can be increased indefinitely by this process by simply increasing the number of volatile liquids which are injected into a given space, and such pressure could undoubtedly be used for the production of work. However, the extent to which Dalton's law is true under such extreme conditions is problematical, and this development represents another phase in physical science which is undergoing investigation at the present time. However, the simple problem of the mixture of water vapor with the atmosphere is, as has been said, fairly well understood and represents today the chief development in which the practical aspect has been forced to the front in view of its great effect under operating conditions.

Now, a word in regard to the method of measuring the amount of moisture present in the atmosphere under various conditions, and some information in regard to its amount and effect in various engineering processes. The water vapor in the atmosphere can be readily removed by any chemical dryer. Thus, if a cubic foot of air or a given quantity is inclosed in a vessel containing lime or sulphuric acid, and the vessel shaken up, if desired, for more complete effect, all the moisture will be removed from the air and the pressure of the latter will fall. This latter phenomenon can be readily seen by opening a stopcock under such conditions, whereupon air will rush into the vessel after such procedure in order to balance the pressure. If the chemical agent, lime, calcium chloride, sulphuric acid, or any well-known dehydrators, is weighed before and after this treatment, the moisture content for this quantity of air is absolutely determined, and a device or mechanism for the performance of this experiment readily and accurately is known as a chemical hygrometer. In actual practice in the physical laboratory this often consists of a tube filled with the drying agent, and suspended from one arm of a delicate balance and through which air is pumped, the air being metered for this purpose and the amount of moisture is at once determinable. However, the process presents capabilities of much modification and means are at hand for ready determination, under any conditions, of the actual amount of moisture, in pounds or grammes, present at any time in any amount of air.

While this value is of great importance under many operative conditions, its relation to another value, namely, the saturation content, is often of much greater significance. This brings us, in reality, to the fundamental differences between what is known as a saturated and unsaturated vapor. In general, a saturated vapor can be defined as a vapor in which the quantity of material held is at its maximum. Any increase in the material present in the space either due to actual introduction, or to an increase in density caused by pressure, will cause a deposition or condensation of a portion of this vapor into its liquid form. It is analogous to what is known as the dew-point in atmospheric conditions, and at this latter temperature the ordinary air contains saturated water vapor. The space above a liquid invariably becomes filled with the vapor of that liquid to its maximum extent, and hence is a saturated vapor. Any variation, as stated, or a diminution in temperature results in a condensation or diminution in the weight of the vapor present. Thus one condition for the presence of a saturated vapor is the presence of a liquid surface of the same material immediately continuous both in regard to time and place. Thus the water vapor in the air is saturated or not saturated, dependent solely upon the presence of large quantities of water in the vicinity or the close time relationship of the air in its contact with this surface. When a gas or vapor is heated, it tends to expand and occupy a larger space. Hence a saturated vapor gradually becomes in an unsaturated condition with rise in temperature, and is capable of absorbing, on contact with its own liquid, an amount of the material in the form of vapor sufficient to render it saturated. The amount of water vapor present under saturated conditions is readily determined from the ordinary steam tables, since these in almost all cases represent conditions approximating those favorable for complete saturation. The amount of saturated vapor which the air can, therefore, hold at any given temperature is readily determined by a reference to the steam tables for this temperature, and this steam pressure in practice is represented by a certain definite fraction of what is known as ordinary atmospheric pressure. The relation of the amount of water vapor present in the air to the amount that the air could contain if the steam or vapor existed in a saturated state, is known as the hygrometric state or percentage of humidity and is of great importance in engineering practice, especially in cooling tower operation and allied phenomena, since it represents the capabilities of the air in regard to its absorptive power for moisture present in surrounding bodies, and hence its cooling effect in cooling towers and its drying capabilities as a dehydrator. While the ratio of the amount of moisture present in any definite amount of air to the amount that it should contain at this temperature, as determined according to the steam tables, is known, as has been said, as the hygrometric state, yet this ratio is numerically equal to a number of other different ratios relating to the same phenomenon. Hence this state is often defined in a number of other ways which often enable it to be measured much more readily and satisfactorily than can be done by this procedure. Thus the pressure of a saturated vapor is a function of the temperature only, and is independent of the volume. Hence the amount of material present in a saturated vapor is proportional to its pressure. In the same way the pressure of an unsaturated vapor is proportional to the amount of material present, if the temperature and volume are kept constant. Hence the unsaturated pressure of a vapor is proportional to the amount present, and the hygrometric state reduces to a ratio of the pressures of the unsaturated and saturated vapors which are present or can exist under given identical conditions. This ratio of the pressures is equal numerically to the ratio of the weights and is known as the relative humidity or the hygrometric state, and with some instruments, designed for this purpose, is much simpler in its determination than is possible by a direct determination of the weights, even though one has been determined and is obtainable from the steam tables. Again, since the pressure of a saturated vapor is directly proportional to its temperature, and somewhat analogous conditions hold for unsaturated vapors, the ratio can be reduced to temperature variations and we have the hygrometric state or relative humidity of a given air content as a simple function of its temperature and the temperature of its dew point, namely, that temperature to which the air must be lowered in order that water shall be condensed or dew produced readily.

Nearly all hygrometers, other than the chemical one, utilize this last relationship for the determination of the moisture content and relative humidity. They consist essentially of two thermometer bulbs, one of which records the temperature under given conditions, and the other is surrounded by some cooling agent whose temperature it records at the time when dew is produced or moisture has become perceptible in this form in the immediate vicinity. Thus the wet-and-dry bulb hygrometer consists simply of two thermometers, one of which has its bulb surrounded with an ordinary cotton wick which has its end immersed in a tube of water. The capillary action keeps the wick moist, and the evaporation into the air produces the cooling effect which is at once perceptible in the reading of the thermometer. The scale with this device is a purely arbitrary one, determined through calibration with a chemical hygrometer or dew-point measuring device, but gives fairly satisfactory and accurate results of the relative humidity. This latter quantity is a quantity which, reduced to percentage and multiplied by the value obtained from the steam tables, gives the amount of water content in a unit quantity or volume of air.

The actual dew-point hygrometer, so called, consists of two thermometers, one for the registering of the atmospheric temperature and the other for the determination of the dew point. This latter thermometer is surrounded by another bulb, into which ether or some other volatile liquid can be poured and rapidly evaporated by passing air through it by means of blowing or by the action of an ordinary water aspirator. This bulb containing the ether is partially covered by a polished metallic surface, and when the cooling effect produced by the evaporation of the ether has continued a sufficient time, this surface will become covered with moisture, due to the condensation of the water vapor present in the air, and the temperature at which this occurs is recorded by the thermometer, which gives the temperature of the boiling or evaporating ether. This device is much more satisfactory than

* Reprinted from Cassier's Magazine.

any of the arbitrary calibrated ones, of which the thread hygrometer is undoubtedly the worst. This consists simply of a silk or specially prepared fiber, fastened to a device for amplification and measuring of its motion, so that small variations in its length can be readily measured. When this fiber becomes wet, it becomes shorter, and its length is roughly proportional to the amount of moisture present in the fiber, which, in turn, is dependent on the amount present in the air. Hence this device can be roughly calibrated to act as a hygrometer by complete reference of its values as arbitrarily determined to a standard hygrometer. However, it is not a sensitive instrument and responds slowly to variations in this state, and hence possesses little value as an accurate measuring device.

This represents a review of the ordinary hygrometric instruments and methods available for this development. The amount of water vapor present under ordinary conditions is comparatively small, being, approximately, 5.85 grains per cubic foot as an average for a five days' test at the installation of the refrigerating plant for the removal of moisture from the blast in iron furnace operation at the Isabella furnace of the Carnegie Steel Company at Ætna, Pa. This represents approximately normal values. It varies, however, from one grain to as high as eight or more, and even considerably larger values represent fairly average conditions in the tropics. The eastern sea coast of the United States represents a much greater hygrometric average than is present in the Middle West, and this latter bears almost an equal ratio to Rocky Mountain conditions. In the installation mentioned, each grain of moisture content per cubic foot meant a water removal of 40 gallons per hour, so that the effect, in the aggregate, is by no means negligible. In addition to its effect in blast-furnace operation and internal-combustion motors and air compression, its significance in cooling towers and their operation is equally pronounced. A cooling tower on a dry day may readily cool steam condenser water of 160 deg. to 200 deg. F., to values as low as 70 deg. or 80 deg. F., whereas on a moist, warm day the fall in temperature may not exceed one-half to one-third of this. The temperature of the air is, in reality, a matter of minor significance, and a number of tests are under consideration by cooling-tower manufacturers, undertaken with a view to the actual introduction of heated air into the cooling tower for the purpose of increasing the cooling effect on account of the increased possibilities in absorption of water vapor under these conditions.

The fact that mechanical refrigeration has been proved to be a most efficient device in the removal of the water present in the air, and the further fact that this mechanical refrigeration can often be produced by the utilization of exhaust steam, a commodity or by-product often wasted under many conditions of installation, represents a condition which permits of its development for this purpose with a comparatively high degree of efficiency. The situation is such that practically no engineer can afford to-day to be without this knowledge in regard to hygrometric conditions, and to have some conception of the effects of the presence of the moisture in the air upon any special process in which he is interested.

CHARLES DARWIN AND MENDELISM.*

EVOLUTION PAST AND PRESENT.

BY A. E. SHIPLEY, M.A. CANTAB., HON. D.SC. PRINCETON, F.R.S.

IT has been somewhat shallowly said—said, in fact, on the day of the centenary of Darwin's birth—that "we are upon very unsafe ground when we speculate upon the manner in which organic evolution has proceeded without knowing in the least what was the variable organic basis from which the whole process started." Such statements show a certain misconception, not confined to the layman, as to the scope and limitations of scientific theories in general, and to the theory of organic evolution in particular. The idea that it is fruitless to speculate about the evolution of species without determining the origin of life is based on an erroneous conception of the true nature of scientific thought and of the methods of scientific procedure. For science the world of natural phenomena is a complex of procedure going on in time, and the sole function of natural science is to construct systematic schemes forming conceptional descriptions of actually observed processes. Of ultimate origins natural science has no knowledge and can give no account. The question whether living matter is continuous or not with what we call non-living matter is certainly one to which an attempted answer falls within the scope of the scientific method. If, however, the final answer should be in the affirmative, we should then know that all matter is living; but we should be no nearer to the attainment of a notion of the origin of life.

No body of scientific doctrine succeeds in describing in terms of laws of succession more than some limited set of stages of a natural process; the whole process—if, indeed, it can be regarded as a whole—must forever be beyond the reach of scientific grasp. The earliest stage to which science has succeeded in tracing back any part of a sequence of phenomena constitutes a new problem for science, and that without end. There is always an earlier stage, and to an earliest we can never attain. The questions of origins concern the theologian, the metaphysician, perhaps the poet. The fact that Darwin did not concern himself with questions as to the origin of life nor with the apparent discontinuity between living and non-living matter in no way diminishes the value of his work. The broad philosophic mind of the great master of inductive method saw too fully the nature of the task he had set before him to hamper himself with irrelevant views as to origins.

No well-instructed person imagines that Darwin spoke either the first or the last word about organic evolution. His ideas as to the precise mode of evolution may be, and are being, modified as time goes on. This is the fate of all scientific theories; none is stationary, none is final. The development of science is a continuous process of evolution, like the world of phenomena itself. It has, however, some few landmarks which stand out exceptional and prominent. None of these is greater or will be more enduring in the history of thought than the one associated with the name of Charles Darwin.

It is a somewhat remarkable fact that while the works of Darwin stimulated an immense amount of research in biology, this research did not at first take the line he himself had traced. With some exception the leading zoological work of the end of the last century took the form of embryology, morphology, and palæontology, and such subjects as cell-lineage, "Entwickelungsmechanik"; the minute structure of protoplasm, life histories, teratology, have occupied the minds of those who interest themselves in the problems of life. Along all these lines of research man has been seeking for the solution of that secret of nature which at the bottom of his heart he knows he will never find, and yet the pursuit of which is his one abiding interest. Had Frank Balfour lived we should, I think, have sooner returned to the broader lines of research as practised by Darwin, for it was his intention to turn himself to the physiology—using the term in its widest sense—of the lower animals. Toward the end of the nineteenth century, stimulated by Galton, Weldon began those series of measurements and observations which have culminated in the establishment, under the guidance of his friend and fellow-worker, Karl Pearson, of a great school of eugenics and statistics in London. With the beginning of the twentieth century came the rediscovery of Mendel's facts, and with that an immediate and enormous outburst of enthusiasm and of work. Mendel has placed a new instrument in the hand of the breeder, an instrument which, when he has learned to use it, will give him a power over all domesticated animals and cultivated crops undreamed of before. We are getting a new insight into the working of heredity and we are acquiring a new conception of the individual. The few years which have elapsed since men's attention was redirected to the principles first enunciated by the Abbot of Brünn has seen a great school of genetics arise at Cambridge under the stimulating energy of Bateson, and an immense amount of work has also been done in France, Holland, Austria, and especially in the United States. As the work has advanced, new ideas have arisen and earlier formed ones have had to be abandoned; this must be so with every advancing science; but it has now become clear that mutations occur and exist especially in cultivated species, and that they breed true seems now to be established. In wild species also they undoubtedly occur, but whether they are so common (in uncultivated species) remains to be seen. If they are not, in my opinion a most profitable line of research would be to endeavor to determine what factor exists in cultivation which stimulates mutation.

To what extent Darwin's writing would have been modified had Mendel's work come into his hands we can never know. He carefully considered the question of mutation, or, as they called it then, saltation, and as time went on he attached less and less importance to these variations as factors in the origin of species. Ray Lankester has recently reminded us that Darwin's disciple and expounder, Huxley, "clung to a little heresy of his own as to the occurrence of evolution by saltatory variation," and there must have been frequent and prolonged discussion on the point. That "little heresy" has now become the orthodoxy of a number of eager and thoughtful workers who are at times rather aggressive in their attacks on the supporters of the old creed. "That mutations occur and exist is obvious to everyone, but that they are of frequent occurrence under purely natural conditions is," Sir William Thiselton-Dyer thinks, "unsupported by evidence." The delicate adjustment between an organism and its natural surroundings suggests that sudden change of a marked kind would lead to the extinction of the mutating individual. As far as I can understand the matter in dispute, Darwin and his followers held that evolution had proceeded by small steps, for which we may accept De Vries's term fluctuations; while the mutationists hold that it has advanced by large ones, or mutations. But it is acknowledged that mutations are not all of the same magnitude, some, e. g., albinism; brachydactyly in man; dwarf habit or glabrousness in plants, may be large; others, e. g., certain differences in shade of color or in size, are insignificant, and indeed Punnett has suggested that under the head of fluctuating variation we are dealing with two distinct phenomena. He holds that "some of the so-called fluctuations are in reality mutations, while others are due to environmental influence." He thinks the evidence that these latter are transmitted is slender, and later states that "evolution takes place through the action of selection on these mutations. Where there are no mutations there can be no evolution." The disagreement about the way in which evolution has proceeded has perhaps arisen from a misunderstanding as to the nature of the two kinds of variation described respectively as mutations and fluctuations. Mutations are variations arising in the germ cells and due to causes of which we are wholly ignorant; fluctuations are variations arising in the body or "soma" owing to the action of external conditions. The former are undoubtedly inherited, the latter are very probably not. But since mutations (using the word in this sense) may be small and may appear similar in character to fluctuations, it is not always possible to separate the two things by inspection alone. The whole matter is well illustrated by the work of Johannsen on beans. He found that while the beans borne by any one plant vary largely in size, yet if a large and a small bean from the same plant are sown, the mean size and variability of the beans on the plants so produced will be the same. The differences in size are presumably due to differences of condition and are not inherited. But if two beans are sown, one from a plant with beans of large average size, and one from a bean of small average size, the bean plant whose parent had the high average will bear larger beans than the one from the parent with small average beans. The faculty of producing a high or low mean size is congenital, is a mutation in the sense used above, and is inherited. It is no doubt unforunate that the word mutation has been used in several different senses, for it seems to have led to most regrettable confusion and misunderstanding.

As I have said, in such a year, and in my position, I ought perhaps to have devoted the whole of this address to the more philosophical side of our subject; but, in truth, I am no philosopher, and I can only say, as Mr. Oliver Edwards, "an old fellow collegian" of Dr. Johnson's, said to the "great lexicographer" when they met after nearly half a century of separation: "I have tried too in my time to be a philosopher, but I don't know how; cheerfulness was always breaking in."

* Abstract of a paper read before the Zoological Section of the British Association for the Advancement of Science.

The monthly report of passenger train performances on the New York steam railways for August, 1909, shows that 65,312 trains were operated, 87 per cent being "on time" at division terminals. In August, 1908, 62,397 trains were operated, 78 per cent being on time.

SUPERHEATED STEAM LOCOMOTIVES.

SOME RECENT EUROPEAN DESIGNS.

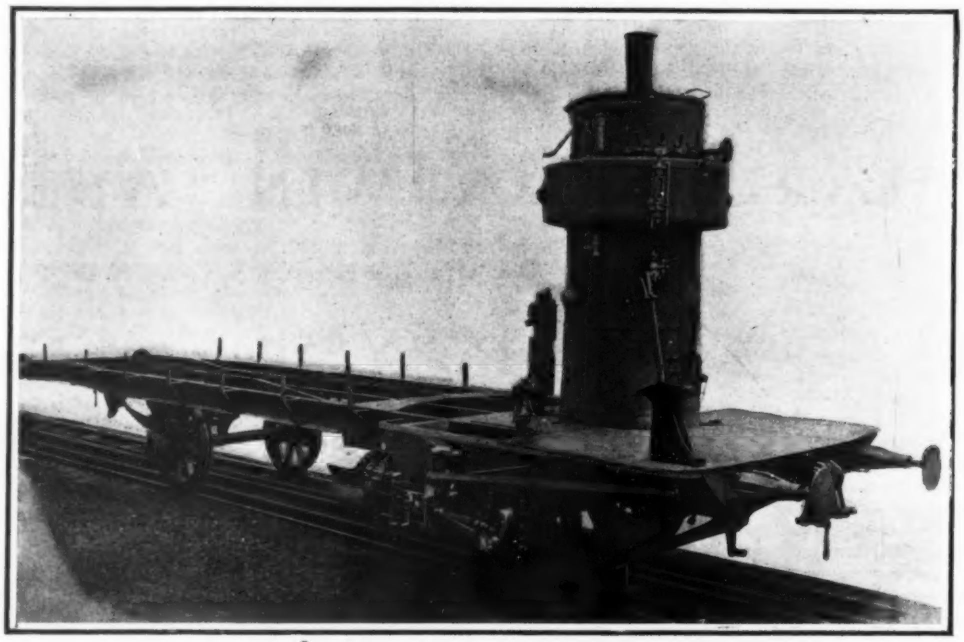
BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

We represent in our engravings two of the most recent German superheated steam locomotives or motor coaches for standard-gage track. The motor coaches of this type are now quite extensively used on the Wurtemburg Royal State Railways where they are giving good satisfaction. The coach is supported on two axles, one of which, the driving axle, is worked direct by a twin steam engine, while the other is fitted as a free axle. In this way it can run in either direction. After the driver's cabin comes the passenger compartment. Between the two, however, there is a small compartment which is used generally for baggage or as a postal compartment. Under the truck there are four closed boxes which can also be used for baggage. In the driver's cabin next the boiler are coal bunker and the water tank. The present coach is built for standard or other gages, and like the locomotive is constructed by the Esslingen works.

The superheated steam which is used for driving the engine is generated in a fire-tube boiler with a heating surface of 362 square feet, placed in the driver's cabin at the front of the coach. The boiler is provided with all the fittings required by the rules, namely, a pressure gage, safety valve, and water gage with two test cocks. Two injectors supply feed water to the boiler through two feed valves. Each injector is capable of delivering the total supply. Although of a comparatively small water capacity, the boiler has a considerable evaporating surface and a large steam chamber. The superheater is built into the smoke box which is placed above the boiler. The cover of the smoke box, together with the chimney and spark arrester, can be turned up to facilitate the cleaning of the superheater and the fire tubes. A special apparatus is used for blowing out the fire tubes. Small lump coal gives the most satisfactory results with the present engine.

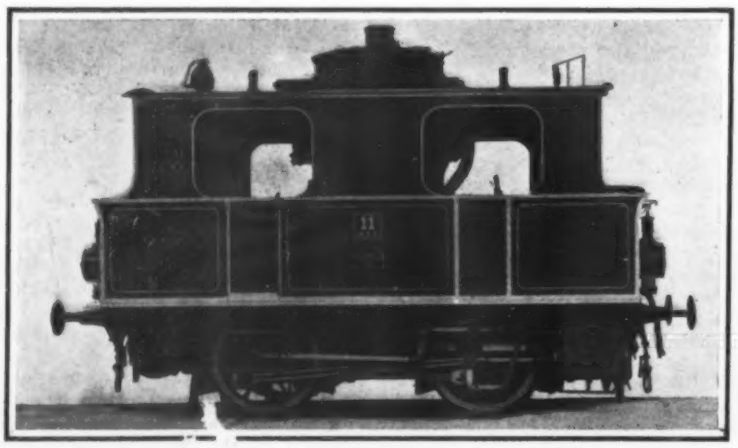
The powerful twin steam engine is constructed on the same lines as that of an ordinary locomotive, the slide-valve movement being of the Walschaert type. Reversing is carried out by means of a hand lever. A pump connected with the driving mechanism supplies oil to the steam cylinders. The maximum speed of the coach is 37 miles an hour forward and 31 miles an hour when reversed. The steam coach is powerful enough to draw one or two trailers, making a total load of 30 tons, upon ordinary gradients. Both at the back of the conductor's platform and also on the driver's platform there are doors with projecting treads and hand rails for communication with the trailers, and these latter can be attached to either end of the steam coach.

The personnel of the steam coach consists of a driver who also acts as fireman, and a conductor. The latter has his post on the rear platform, where he controls the brake, steam whistle and bell, when the coach is running backward. Management of the boiler requires no special training, but can be intrusted to the care of any mechanic who is accustomed to locomotive boilers. Heating of the coach is carried out by using the exhaust steam during the trip and fresh steam when the coach is at rest. The following are the principal data: Cylinder diameter, 8.67 inches; stroke, 11.8 inches; wheel diameter, 3 feet 3 inches; total heating surface, 362 square feet; grate area, 7.7 square feet; boiler pressure, 230 pounds per square inch; wheel base, 16 feet 5 inches; length of coach over all, 34 feet 2 inches; width, 10 feet 1½ inch; capacity of water tanks, 330 gallons; coal bunkers, 875 pounds; seating capacity, 40 places; weight empty, 17.6 tons; in running order (without passengers), 20.7 tons; average power, 80 horse-power; gage, 4 feet 8.5 inches. The locomotive can draw a 30-ton train on a level at 34 miles an hour, and on a 1 in 100 gradient at 20 miles an hour with a water consumption of 14 gallons and a fuel consumption of 21 pounds per mile, giving 100 horse-power on the engine.

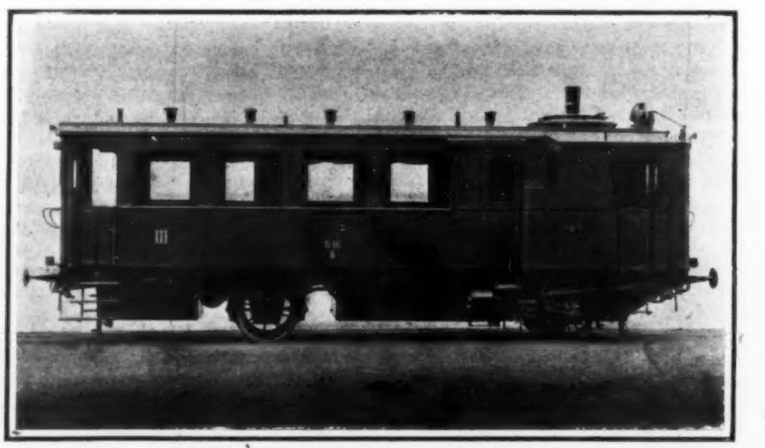


DETAIL OF STEAM COACH CHASSIS.

A type of small superheated steam locomotive built by the same firm is also shown here. It is used on the lines of the West German railroad company, upon standard-gage tracks, and the maximum speed is 30 miles an hour. The present locomotive is able to draw a 65-ton train consisting of three four-axled passenger cars up a gradient of 2 per 100. The locomotive has a wheel spread of 7 feet 7 inches, and a 4-foot 8½-inch gage. The chassis is supported on the axles by means of elliptical springs. Couplings and buffers follow the standards of the Royal Prussian railroads. The steam cylinders are placed one on each side and at the front of the chassis, while the method of coupling by bars to the two wheels will be observed. Built of angle iron and plate, the chassis is of a solid construction. The valve mechanism is of the Waldegg type. Regarding the superheated steam outfit for the locomotive, it uses a type of boiler patented by the Esslingen firm, this being mounted upright in the middle of the chassis and between the two axles. The fire-tube boiler is built for a pressure of 16 atmospheres. Such boilers have been in use for some time on the Wurtemburg State Railways and other railroads in Germany. Superheated steam at 270 deg. C. is delivered, the total heating surface being 648 square feet, and the grate surface 12 square feet. The cylindrical boiler is expanded in the upper part so as to provide a great steam space and a considerable surface. Above in the smoke chamber is mounted the superheater. On the boiler are mounted two safety valves of the Coale type, and we have the needed apparatus such as injectors, gages, etc. The locomotive is built so as to allow of inspecting the track from either end, and there is a control bench placed at each end containing all the needed apparatus. Doors and platforms at both ends of the locomotive allow the driver to enter the train at will.



SUPERHEATED STEAM LOCOMOTIVE.



COMBINED COACH AND LOCOMOTIVE.

A paper was recently read before the American Institute of Electrical Engineers by Mr. J. B. Taylor which dealt with "Even Harmonics in Alternating-current Circuits." It is customary to assume that the electromotive force wave shapes of commercial generators do not contain even harmonics. If both the winding and the north and south poles are asymmetrical, even harmonics appear. In three-phase transmission also, when the neutral points of the transformers at both the generating and distributing stations are earthed, leakage direct current may flow through the windings, and so, the magnetic field being asymmetrical, even harmonics are produced. The author's oscillograph records of the magnetizing currents in transformers when affected by direct current show that a pronounced second harmonic is often produced. When a rotary converter is connected with a direct-current three-wire system of supply, the magnetic field is asymmetrical, and even harmonics appear in the wave shapes of currents and electromotive forces. The author has previously suggested the use of counter-electromotive force cells—similar to storage batteries with plates unformed—to check leakage direct currents.

THE TURBINE YACHT "WINCHESTER."

A FAST AMERICAN CRAFT BUILT ON THE CLYDE.

The fast steam yacht "Winchester," constructed by Messrs. Yarrow of Glasgow for an American owner, recently passed her trials in the Firth of Clyde. The estimated speed was 26 knots, and the mean speed obtained on a two hours' trial was 26.7 knots.

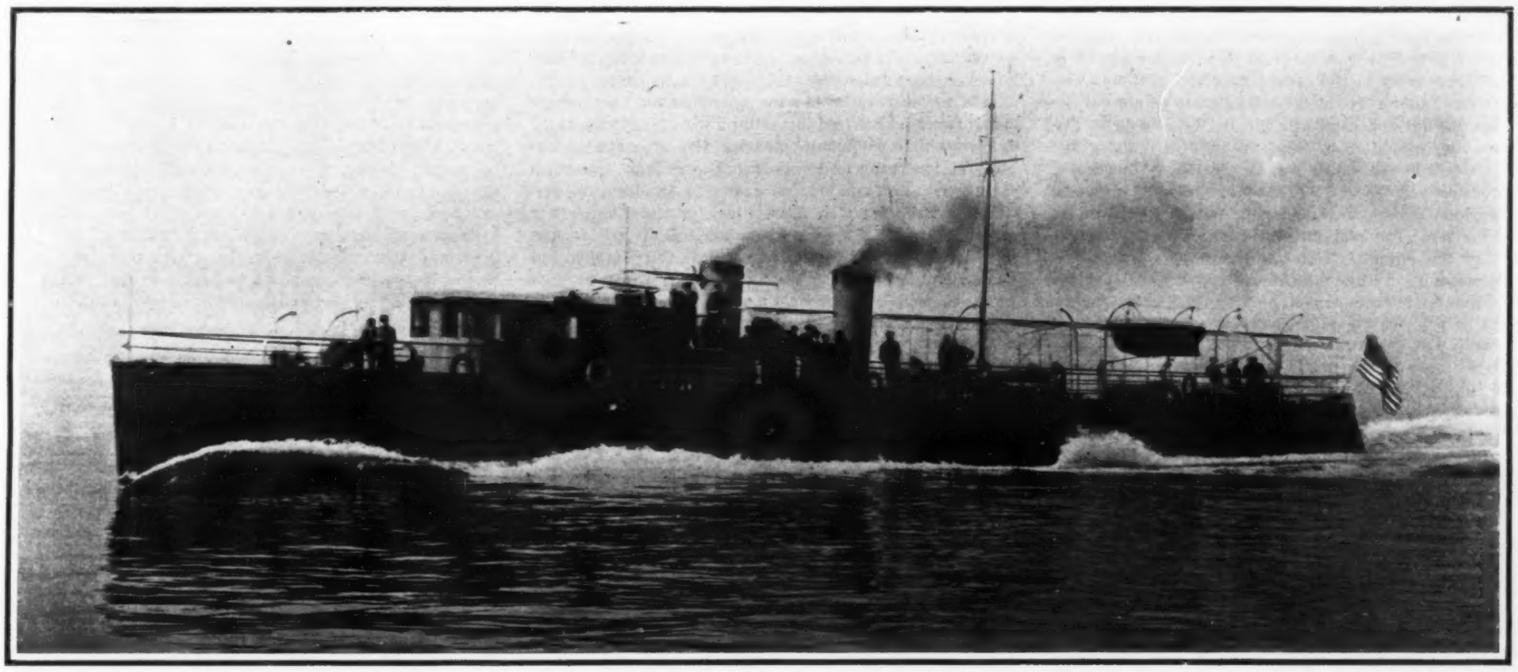
The dimensions of the vessel are: Length, 165 feet; beam, 15 feet 6 inches. She is built on torpedo-boat lines.

The propelling machinery consists of three turbines of Parsons type with three shafts, one propeller on each shaft. The port shaft is actuated by a high-pressure turbine; the center shaft by a low-pressure turbine in which is incorporated an astern turbine, and the starboard shaft by a middle-pressure turbine.

Steam to the turbines is supplied by two Yarrow water-tube boilers, constructed for burning oil fuel exclusively.

The accommodation for the owner, which is below deck abaft the machinery space and is very commodious and handsomely decorated, consists of a double stateroom, two single staterooms, drawing room, bath room, and toilet rooms. There is a teak deck house forward, 25 feet long, containing dining room, captain's cabin, and pantry. The quarters for the officers and crew and the galley are below the main deck forward.

The vessel has a complete electric light installation, and is heated by steam.



THE TURBINE YACHT "WINCHESTER." SPEED, 26.7 KNOTS.

REMODELING GASOLINE (PETROL) ENGINES FOR PRODUCER GAS.*

By H. F. Smith.

Among manufacturers of internal combustion engines who have, up to the present time, been confining themselves largely to gasoline (petrol), there is a strong temptation to enter the producer-gas field, not by redesigning an entirely new engine but by undertaking to adapt the existing design to the requirements of producer-gas work. In many instances this can be done with a fair degree of success, but the degree of success obtained will depend entirely on how well the essential conditions of design requisite for operation on producer-gas can be embodied in the existing structure.

There has been in the past an unfortunate impression among builders of this class of engines that about all that is required to make a gasoline (petrol) engine successful for producer gas is to increase the compression to about 150 pounds per square inch. As a matter of fact this is perhaps one of the least important of the several requirements for successful operation on producer gas. There is no reason why compression with producer gas is a matter of any greater importance than it is with gasoline (petrol). A gasoline (petrol) engine, operating under an initial compression of 80 pounds per square inch, will give a higher efficiency than one operating under an initial compression of 30 pounds per square inch. The same may be said of engines for producer-gas with exactly the same force, except that with producer-gas it is practical on account of the characteristics of the fuel to carry the compression to points that cannot be tolerated for gasoline (petrol). Experience has shown, however, that under ordinary conditions the heat losses introduced by abnormally high compression, together with the increased friction and strain on the various parts of the engine, soon become greater than the increased efficiency of the cycle, and there is, therefore, very little gain, and, in some cases, a positive loss, by carrying compression above comparatively moderate limits. No further consideration need be given this point than to note that 150 pounds per square inch gage is perhaps more ordinarily used than any other pressure for producer-gas.

Briefly, the main points to be considered in an engine designed for producer gas are: First, the size and location of the inlet and exhaust valves and passages; second, the contour and dimensions of the clearance space; third, the provision of an ample and effective ignition gear. If these three major elements of design are in line with the best practice, the question of compression can be very safely left to take care of itself. If, on the other hand, it is impossible or inconvenient with the existing design of parts to secure ample valve area, properly shaped clearances, and a thoroughly good ignition, it is perfectly safe to assume that no amount of compression will make the engine satisfactory for operation on producer-gas.

The matter of valves, both as to their location and area, is of great importance. The velocity of gas travel through the ports, both for inlet and exhaust gases, should never be permitted to exceed approximately 80 feet per second. A much lower figure than this will give more satisfactory results. If we assume the customary piston speed of 700 feet per minute we might arbitrarily establish the clear internal diameters of the inlet and exhaust valves at approximately 0.45 times the cylinder diameter. The cages and passageways leading to the valves proper should also be of extremely ample dimensions, particularly the exhaust passages. Not only should the piping and connections be of ample area, but they should also be provided with very easy curves, and all sharp turns or angles in the exhaust manifold connection should be studiously avoided.

The location of the valves necessarily varies with the type of engine. In general, however, the location of the valves has a very notable effect on the shape of the clearance or combustion chamber; for the highest efficiency the clearance or compression space in the end of the cylinder should have a minimum of exposed heat-absorbing surface in proportion to the volume of the charge. This means that the valve should by all means open directly into the combustion space, and that all pockets or any other notable irregularities of the contour of the combustion chamber should be discountenanced. Engines for use on producer-gas must never have any small communicating openings that do not close up flush with the internal surface of the combustion space. Relief cocks and air-starter connections, as well as taps for indicator connections, priming cocks, etc., must all be fitted with plugs or valves closing down flush with the internal surface of the combustion space. Failure to give careful attention to this feature will invariably result in very annoying prematures and back firing.

The question of ignition cannot be given too careful attention. Not only should the mechanism be perfectly reliable, but the source of current must be such as to give a very unusually heavy and hot spark. Ignition devices suitable for use on gasoline* (petrol) are frequently entirely unsuited to producer-gas. Electric ignition should, of course, be utilized exclusively, and the writer is personally very much inclined to favor a thoroughly substantial form of make-and-break igniter, either mechanically or electrically operated. Electrically-operated igniters of this kind should be supplied from a current source giving not less than 40 E. M. F., and capable of supplying from 2 to 5 amperes of current. For mechanically-operated make-and-break igniters a smaller current supply will suffice. Ordinarily, a storage battery of 10 to 12 volts E. M. F., and a fairly low internal resistance, will give entirely satisfactory results. Dry batteries and primary batteries of any ordinary type are not well adapted to this service, and storage batteries for ignition purposes, together with small dynamos for charging same, are worked out to a degree of perfection that makes the use of any other form of ignition a needless experiment.

The best results are secured when the point of ignition is located very close to the geometric center of the compressed charge. On cylinders over 12 to 14 inches in diameter the question of multiple ignition is worthy of careful consideration.

Coming to the matter of speed regulation, producer-gas lends itself to several different methods of governing, but it is by all means best to adopt some form of throttling governing by which an impulse is secured on each regular stroke. Probably the best method is that which involves the throttling of the quantity of the discharge with constant quality of mixture by limiting the lift of the gas inlet valve. Governing by varying the quality of explosive mixture with constant compression can also be worked out in a very satisfactory way for producer-gas. The success of this method is due largely to the extremely wide variations of mixture which are explosive when producer gas is used as a fuel. This method has not been used as much as the former method, but the writer sees no reason why it should not be equally successful.

One point in connection with engine design which usually receives very little, if any, consideration on the part of the average builder is the question of the proper control between the proportion of air and gas where the method of governing by constant quality of mixture is employed. It is of the greatest possible importance, particularly in multiple-cylinder engines, that the quality of the mixture in each of the several cylinders be controlled at one point and that by the

* Abstract of a paper on "Gas Engine Construction for Producer-Gas Use," read before the National Gas and Gasoline (Petrol) Engine Trades Association.

single movement of one lever or valve. Furthermore, it is very important that this lever, or valve, should have attached to it an indicating device, showing at a glance the amount of air opening for any given position, since under normal conditions it is c stomary to run suction producer plants with the gas valve wide open, and control the mixture by closing down to a greater or less extent on the air pipe.

Another question comes up in connection with the remodeling of existing designs that is in some particulars deceptive and apt to lead to disaster. We refer to the strength of the various parts of the gas engine. A producer-gas engine of given cylinder bore and given stroke will develop anywhere from 20 to 30 per cent less power than a gasoline (petrol) engine of the same dimensions. It is quite natural, therefore, to assume that the stresses on the various parts when operating on producer-gas will not be so severe as when operating on gasoline (petrol). The manufacturer, however, must not lose sight of the fact that the higher compression ordinarily employed with producer-gas involves at the same time higher initial explosion press res, and consequently greater strain on the various parts, than where gasoline (petrol) is used as fuel, even though the mean effective pressure and the consequent power is less. It is, therefore, ordinarily not sufficient to take a gasoline (petrol) engine of given cylinder dimensions and correct only the valve areas, clearance, compression, and ignition, to make it suitable for producer-gas work. It is usually necessary at the same time to materially increase the strength of all working parts. These remarks, of course, apply particularly to small engines that are not ordinarily subjected to careful analysis as regards the stresses on the various elements. Larger engines are usually checked over with great care, and remarks of this character as to the strength of the various parts of the mechanism wo ld be entirely out of place.

There is not space within the limits of a brief discussion of this kind to take up in detail all of the various features of design that contribute to success in producer-gas work. We can only casually mention the various questions that can be raised in regard to such matters; for example, the cooling of the various parts of the engine. There is room for a great deal of discussion on the question of water-cooled valves and cages and water-cooled pistons. Effective jacketing is at all times a matter of importance, but thorough cooling of every portion of the engine is of double importance where high compressions are employed, as is the case with all producer-gas work.

The question of ignition control is another matter that involves a great deal of possible disc ssion on both sides. It is, of course, always essential to provide means by which the time of ignition can be advanced and retarded while the engine is in operation, and it is preferable that the exact point of ignition be indicated by the position of the mechanism. There is also a strong tendency on the part of many builders to advance and retard the spark for different loads, to compensate in part for the variation in flame propagation, due to change either in quality or degree of compression of the mixture.

We wish to take occasion at this time, however, to mention, casually, one producer bugaboo that has been the cause of considerable anxiety in the past, but which we believe to be at the present time strictly within the class of those things that are thoroughly understood. We refer to the question of hydrogen content for producer gas. Several years ago every manifestation in a producer-gas layout that was not thoroughly understood was attributed to the presence of hydrogen in the gas. It has probably been held responsible for more different kinds of tro ble than any other single element, and has in all probability been responsible for few, if any, of the various deeds of evil that have been laid at its door. We will take pains at this time to enumerate a few of these features, as it is quite possible that they may come up again to cause aggravation and annoyance, and perhaps throw discredit on producer-gas power.

Several years ago, back-firing was a very common fault of producer-gas operation, and this was almost universally attributed to excess hydrogen. It has, however, been fully demonstrated that hydrogen in the gas is never responsible for back-firing. This condition may be produced by a number of defects, chief among which we would mention the presence of unplugged indicator and relief cock openings communicating with the combustion space, fa lty location and timing of the ignition mechanism, or the overheating of either metal surfaces or carbonized oil within the combustion space. Preignition of the compressed charge is another matter for which hydrogen was long held responsible. It was maintained that owing to the extremely inflammable nature of hydrogen, it would frequently ignite during compression, causing excessive pounding and other similar unpleasant manifestations. The writer has yet to observe a single authentic case of preignition that was due to the presence of hydrogen. We have personally observed the operation of engines on which the compression was run up experimentally to as high as 220 pounds per square inch when supplied with gas containing 27 per cent free hydrogen, without any sign of preignition. On the other hand, we have had violent pounding on engines with not over 125 po nds compression, when operating on gas containing not to exceed 12 per cent hydrogen. When we consider that the ignition temperature of hydrogen is only a little over 100 degrees lower than that of carbon-monoxide, and that if we assume the most unfavorable condition, namely, a temperature on the charge at the beginning of the compression stroke of 212 deg. F., and strictly adiabatic compression with no loss of heat, a compression of something over 300 pounds per square inch would be required to reach the ignition temperature of hydrogen. The improbability of preignition from this source is immediately apparent. One characteristic of hydrogen, however, must not be lost sight of, namely, the fact that flame propagation is very much more rapid through hydrogen than through carbon-monoxide. In other words, an explosive mixture containing a high percentage of hydrogen will be completely burned in a very much shorter time after the occurrence of the igniting spark than would be the case where the hydrogen percentage is low and the comb stible gas largely carbon-monoxide. A sudden variation in the hydrogen in producer gas may be the cause of violent pounding, not through any spontaneous ignition of the charge from compression, but on account of the more rapid rate of flame propagation having the effect of abnormally advancing the time of ignition, the resulting pounding being due to the fact that the igniter is set quite too early for the correct ignition of a mixture with so high a rate of flame propagation. It may be stated, therefore, as a fairly well-established fact, that a properly designed gas engine will handle producer-gas with any possible continuous percentage of hydrogen without any irregularity in operation whatever, and that whatever irregularities may be traced to the hydrogen content of the gas are due rather to the variation in percentage of hydrogen than to the actual amount present.

BALLOONS AND DIRIGIBLES IN WAR.*

CONSIDERATIONS FOR THE STRATEGIST OF THE FUTURE.

BY MAJOR H. L. HAWTHORNE, COAST ARTILLERY CORPS.

In a future war of real seriousness, combatants must expect to be confronted with the necessity of meeting and of preventing the enterprises of mechanisms capable of rising in the air and, in certain types, under the direction of human will, above the theater of operations.

The several types of air craft may be classified as follows:

1. Balloons, lighter than air, capable of rising or falling in the air, but otherwise helpless;
2. Dirigibles, divided into:

(a) Dirigible balloons, lighter than air, provided with means more or less adequate for movement in all directions; and

(b) Aeroplanes, heavier than air, dependent wholly on mechanical form, power, and arrangement for direction in flight.

For war purposes, the ordinary gas balloon, as a rule, will be held captive for observation of terrain occupied or probably to be occupied by the forces of an enemy. Its vulnerability to artillery fire, due to its size, inflammability and comparative immobility, render its near approach to hostile lines almost impossible. The value of observations made from captive balloons under ordinary circumstances will therefore be somewhat small. Should such a balloon attempt flight over hostile territory under favorable conditions of wind, its altitude must be so great in order to avoid destruction that observation in sufficient detail to be of importance to any army commander could not be made. Besides, the chances are that either the results of such a flight will never reach its own headquarters, or the reports suffer such delay that the observed situation will have been wholly changed in the interval, therefore no positive reliance can be placed on the use of such a balloon with a mobile army. It might, however, find a proper and dependable sphere of usefulness in siege operations.

The progress made in the development of dirigibles during the past few years and the feverish efforts now proceeding in certain countries leave no doubt as to the probable presence of a new type of weapon on the future fields of operations, whether used as a means for reconnaissance or for actual offensive activity. Experiments with guns now in service indicate that such equipment is inadequate to oppose successfully the peculiar powers of these mechanisms. There is a demand therefore for weapons constructed with special view to combat dirigibles of whatever type; and their calibers, ballistic qualities, mountings, character of ammunition and mobility must be dependent on the construction, powers and the several peculiar characteristics of airships.

Practically all types of dirigible balloons constructed or undergoing experimentation consist of an envelope filled with gas or a hard rubber envelope containing a vacuum, and varying in length from 100 to 400 feet, and in maximum diameter from 20 to 60 feet. This envelope retains a rigidity of form by the gas pressure, or by an interior air bag, or by a steel, aluminium or wooden framework, or a combination of two or more of these. From one to three gasoline motors are supported on a hanging frame or gondola; and speed is imparted by huge propellers, while direction of movement is controlled by propellers and fin-like rudders.

Bearing in mind the principles of construction and dimensions as above stated we may place against this type of airship the following disadvantages, from the viewpoint of the artillery:

1. Great visibility and area, as a target;
2. Danger of destruction through ignition of gas;
3. Lessening, or deprivation of, buoyancy due to the puncturing or ripping of the envelope;
4. Annihilation of personnel;
5. Destruction of propulsive and controlling parts, such as motors, connections, propellers, rudders, etc.

The artillerist must consider also the powers attainable in an airship to be met and overcome in order to take advantage of the weaknesses above named. These are: ability to change its range by changing its altitude, or direction, or by a combination of these two; power to rise beyond the reach of artillery fire; high speed, making changes of range too rapid to measure or to follow.

From a viewpoint of the aeronaut, certain disadvantages are inherent in the airship, such as danger from the elements, need of protection by housing when not in use, difficulty of replacement of wasted or exhausted gas.

Efforts in the direction of an increase in speed will in time enable the dirigible to face rather severe storms. Several designs now in course of construction, or trial, contemplate the attainment of a speed of fifty, sixty, and even eighty miles an hour.

The dirigible now actually in service appears to require the protection of specially designed sheds with inclosures equipped for receiving the airship at the end of flight and placing it under shelter. This is mainly due to the principle of the rigid or semi-rigid, non-collapsible framework within the envelope. This condition will prove a very serious restraining influence on the mobility of such a dirigible when present with an army acting on the offensive, because with these expensive sheds becoming daily more distant from the heads of moving columns their effective radius of action decreases. This difficulty has been fully recognized as shown in one design in which the envelope is made to collapse within the frame, which in its turn is constructed to lend itself to easy transportation.

Numerous experiments have shown that the mere puncturing of the gas bag of a dirigible will prove no more harmful than an annoyance. The subdivision of the interior of the gas bag into compartments, the rigidity of the supporting framework, the special qualities of the material of the envelope, the great pressure of the confined gas and the large surplus buoyancy, tend to close apertures made by the direct hits of shell or fragments of shrapnel, or to neutralize loss of gas should the rents not be automatically sealed.

The destruction of the propulsive and controlling

* Journal of the United States Artillery.

parts would not necessarily put the airship out of action, which might even then accomplish the purpose of its flight as a simple gas balloon.

Naturally the annihilation of the personnel would render its enterprise innocuous and possibly might end in the ruin or capture of the dirigible itself; but an offensive plan based on the selection of the crew as a sole target whose visibility must be extremely small would leave too much to chance for success.

These considerations lead to the belief that only by the ignition or rapid escape of the contained gas can the airship be successfully opposed. This object, taken in conjunction with the great speed of the dirigible and the facility with which it can maneuver, suggests an expression of views as to type of weapon and character of ammunition to be used against a target of this nature.

In the construction of gun, carriage, mounting, and ammunition we should aim to produce the following qualities:

1. High muzzle velocity.
2. Automatic loading and withdrawal of case.
3. Great stability of carriage.
4. Rapid and easy laying both in azimuth and elevation.
5. All-round fire and angles of elevation up to 70 deg.
6. Indication of flight of projectile by a smoke tracer.
7. Combination fuze, with percussion element sufficiently sensitive to insure bursting on impact with the gas envelope.
8. Contents of projectile such as to cause inflammation of supporting gas, either by heat or by chemical union.

The above qualities might be regarded as common to all balloon fighting guns, whether intended for use with a mobile army, in seacoast defenses, or on board ship.

There are, however, characteristic conditions in each of the above uses of balloon guns which will demand special type of construction both of gun and of mounting. To accompany a field army, the piece must have mobility, comparatively light ammunition and simplicity of range finding equipment. This in turn requires a small caliber, small ratio of weight of gun to carriage, fixed ammunition and shell only, and an extremely flat trajectory. The restrictions which mobility and a necessarily simple position finding system impose lead naturally to a gun of the smallest weight consistent with high initial velocity, flat trajectory, and adequate explosive, igniting or mining effect of the projectile. Heavy ammunition and hence a heavy gun involves complications in recoil and counter recoil mechanism, aggravated by the great angles of elevation likely to be used. No matter what caliber weapon may be selected, the need for broad dangerous spaces must bring about the construction of long guns with high velocity, involving great pressure and speed of recoil. In order therefore to retain the desirable ballistic features and at the same time secure simplicity of mechanism and adequate mobility, it is thought that a 3-pounder or 6-pounder gun (preferably the latter), fifty calibers long, so mounted as to allow all-around fire and an arc of elevation from zero to 70 deg., will meet these conditions, provided that there be high initial velocity, fixed ammunition loaded from a belt or drum, breech mechanism automatic in action throughout the cycle of loading and firing, the projectile to be shell only, provided with a smoke tracer, and having thin walls, and containing a comparatively large charge of some substance of high calorific value. The principles and details of construction of mounting should have in view: short recoil; rapid movements in elevation and direction; direct laying by sight elevations; perfect stability of carriage; and a celerity and ease of movement from point to point over a threatened area.

The choice of projectile for balloon gun firing is a matter on which diverse opinions have been given. The shrapnel has the advantage of great searching effect, aid in ranging by time bursts and probable large number of perforations of the balloon envelope. On the other hand bullet or fragment perforations are but slight injuries; the fuse setting could seldom if ever be the same for any two consecutive shots and because of the larger caliber, slower rate of fire and a less flatness of trajectory than the smaller shell firer, the advantage of greater searching effect would be much decreased.

In the Krupp type of field gun and carriage for balloon firing—the farthest developed, so far as known to the writer—there are to be noted the many sacrifices made to the selection of a large caliber weapon. In order to avoid wide changes in azimuth of the top carriage the wheels are made to hinge on the axles and to move to a position on the arc of a circle, centered on a pintle in the trail spade. There follows from this arrangement, coarse methods of changes in azimuth (the top carriage allows but 3½ deg. on each side of the normal), involving effort, slowness, and inaccuracy, together with elaboration of mechanism quite out of place in a field carriage. The difficulty of loading by hand is met by modifications in the shape and action of the breech block, claimed by the inventors to be adequate, while the need for pivoting the gun near its breech (a direct result of its mass in recoil) compels the introduction of an equalizing mechanism, dependent for its thoroughness of action on the uncertain life of spring coils.

With the recognition of the inflated body of the airship as the principal if not the only proper target, designers of projectiles are seeking the best contained composition to bring about its destruction. Various methods have been devised, based upon the inflammability of the confined gas, such as an explosive substance of high calorific power; shrapnel which on bursting release darts carrying flaming attachments for setting fire to the envelope and finally to the gas within; and projectiles filled with a substance which, on being exploded within the gas bag, releases a vapor capable of forming a destructive or neutralizing chemical union with the gas. Other designs contemplate a ripping of the envelope sufficiently seriously to reduce the buoyancy with dangerous rapidity, such as shrapnel bullets joined in pairs by chains or wires of varying lengths; or projectiles with metal wings contained within the head, which, on impact with the balloon, are extended and produce irregular tears in the envelope. There are obvious objections to all devices dependent on probable mechanical automatic action; and it is thought that the most certain means of destruction lie with an explosion on impact of such a character as to unite the tearing and flaming effects such as might be accomplished by a shell with a large charge of substance giving intense and prolonged heat.

In the selection of a range finding system to accompany and work in co-operation with the operations of field guns in attacks on airships, the quality to be sought for is reasonable accuracy consistent with rapid work at a moving target. Predicting would be rarely possible and all that might be fairly expected from even the best system would be ranges taken at equal and short intervals with data as to speed and general course of target.

The mount should be fitted with a sighting device having lenses and reflectors arranged for the unconstrained use of the layer at the steepest angles of elevation. Laying should be direct and angles or ranges taken in conjunction with a relocating or correcting device whose advantages are the angular elevation of the target and the projection of the range on the horizontal plane; or, in other words, an automatic correction for the effect of altitude of target on tables of ranges based on the theory of the rigidity of the trajectory. This might be accomplished by sight drums having curves of ranges corrected for known altitudes or angles of elevation, and possibly attached to the sight itself; or it might be a separate instrument whose mechanically obtained results could be applied to a scale based on the ordinary tables of elevation.

When the employment of dirigible balloons against seacoast defenses, or more or less elaborate land fortifications, is to be considered, several factors, peculiar to a condition of comparative immobility, enter the problem; at the same time there occurs an elimination of certain restrictions characteristic of the use of balloon guns with a mobile army.

The question of mobility is no longer vital; hence the weights of gun and carriage, complications of mechanism of recoil and counter-recoil, and ammunition supply, no longer influence restrictively the caliber and breech movement; hence a larger gun with longer recoil and hand loading methods can be adopted, keeping always in view, however, the necessity for high speed in laying.

With the larger calibers there may be considered a greater variety of projectiles; and the advocates of the shrapnel, designed for the principal object of destruction of the envelope or contained gas, may here find a field of usefulness. The shrapnel must always be a menace to friendly troops when fired at very high angles of elevation which will naturally be required most often. The construction of such projectiles should have in view therefore the elimination, to as great an extent as possible, of all danger from this source. This might be accomplished by having the shrapnel filled with inflammable substances only and the body pulverized by a detonating charge; or so arranged as to bring about a final destruction of its contents after attaining its object at the target. The shrapnel has the advantage of offsetting by the depth of its cone of dispersion, a certain percentage of error in measuring or estimating ranges. On the other hand, the burning of the time element of the fuse is rendered uncertain by the unknown atmospheric conditions at high altitudes. Furthermore, considering that rapidity of fire is so essential, and the changes of range so continuous and so irregular, the delay necessary to select and make the fuse setting is too serious a loss of time. Still it must be admitted that military opinion to a large extent favors the use of shrapnel against airships.

Notwithstanding that mobility is not a governing quality in the principles of construction of a gun and carriage for use in seacoast defenses in contests against dirigible balloons, still the piece should be able to move with certain celerity from point to point, especially in a command covering an extensive area, which in time of active operations would include the land defenses, extending, in many cases, over a great many miles of territory.

The most economical and the best tactical distribution of such guns would be on the extreme flanks of the position, with such additional pieces between these as the requirements of effective cross-fire may demand. Their habitual positions should be protected and sufficiently withdrawn from the front as to secure immunity from the fire of opposing field artillery, but not so far that their own fire at high angles would endanger their own troops. These positions should be connected by a protected railway line for which the gun mountings should be designed. This would give a means for concentration and also permit of securing more advantageous directions of fire with reference to light, wind, and the presentation of the target.

The standard fire control system used in seacoast works could be employed in conjunction with the fire of these guns, less elaborate perhaps, but insuring rapid position finding and transmission of data to the guns. These data would largely deal with ranges and altitudes of targets and be of a nature to conform to direct methods of laying. Even predictions might be attempted whenever the movements of the dirigibles permitted; and relocation would be governed by the establishment of numerous points along the line of railway previously selected and plotted.

The installation of balloon guns on board men-of-war can never be satisfactory. All the factors which make firing at airships difficult and uncertain on land will be augmented by the instability of the gun platform, which in this case counts for more than when the target can move in but one plane. The single advantage lies in much less danger to friendly forces in fire at high angles. The best type of gun and mount would be a small caliber, high velocity weapon, mounted well above the deck and designed for close hand fighting.

The aeroplane, as an object of unfriendly opposition, may offer even more of a problem to the artillerist in war than its more cumbersome brother, the dirigible balloon. However, its present state of development is far behind that of its competitor, both as to sustained flight and rapidity of movement. Although it seems to maneuver with equal if not better celerity, its flight is close to the ground, its buoyancy excess small, and its speed so limited as to be unable to face air currents of any pronounced strength. In the development of this dirigible, all these low order qualities may disappear; but there must still remain a delicacy of construction and material which suggests the best means of effecting its destruction by gun fire. The numerous trials of this type of dirigible show clearly that its active life hangs almost literally by a thread. Even if ruin should not follow certain slight injuries, its immediate withdrawal from the upper air becomes imperative. Thus, so far as sensitiveness to injury is concerned, it becomes an ideal target for any projectile arranged to break up into many widely dispersed fragments.

The field gun above outlined, with a shell provided with a time fuse, still remains the proper weapon for any dirigible; and shrapnel as suggested for use in the seacoast balloon gun fulfills the same office. Therefore, no change in gun design is brought about by the presence of this type of aerial craft.

In conclusion, it seems proper to say that the above suggestions as to the best form of balloon fighting gun and the requirements thought most likely to be demanded by the character of its service are based to a large extent on the claimed possibilities in the development of the airship, rather than on the present state of the science of aerial navigation. Thus far promises and predictions are much in advance of accomplishment; but the intensity of effort now being given it, particularly abroad, indicates an earnestness of purpose which may bear fruit to the discomfiture of military administrations found wanting in foresight and diligence.

Reinforced concrete telegraph poles have now been in use on the Pennsylvania Lines West for two years, and while erected in only a few places, are reported to be giving satisfaction where sufficient time for observation has elapsed. The first poles of this description, erected near Maples, Ind., were built after an elaborate series of experiments on both wooden and reinforced concrete poles, which were described by Mr. Robert A. Cummings at the 1907 meeting of the American Society for Testing Materials. These poles are still in service, and though they were within the belt of influence of the severe sleet storm of February 15th of this year, none of them showed any signs of failure. The latest installations are those near Crestline, O., and through the town of New Brighton, Pa. The poles are 30 feet long, 14 inches in diameter at the bottom, and 6 inches at the top, and at present carry one cross-arm, accommodating eight wires.

THE MAKING OF AUTOMOBILE TIRES.—II.*

FROM RAW MATERIAL TO FINISHED PRODUCT.

BY SNOWDEN B. REDFIELD.

Concluded from Supplement No. 1767, page 314.

MOLDING AND VULCANIZING.

After the beading has been put in and the edges tucked down and reinforced, the core is removed from the central arbor, and with its fabric and rubber covering is placed in a mold, as shown in Fig. 6. When the cover is placed on the mold over the core and the rubber fabric, the application of pressure to the two sides of the mold will squeeze the rubber fabric tightly and a pile is made of these molds in a hydraulic-press vulcanizer, as shown in Fig. 6. After the shelves have been filled with the molds, each containing an unvulcanized tire with its cast-iron core, the whole framework is allowed to drop down into a large cylinder, and by means of the hydraulic rams heavy pressure is put upon the molds.

While this pressure is being exerted, steam at about 275 deg. F. is blown into the vulcanizing vessel, and the action of the heat causes a chemical combination between the rubber and the sulphur and other chemicals of the vulcanizing material. Also the pressure of the mold makes the different layers of the tire fabric stick tightly together and knit into practically one fabric, while the rubber loses its sticky nature and becomes what we know as vulcanized rubber.

The process of vulcanization is not completed in these molds, for as yet the tires are not provided with the outer coating or tread. This tread is an extra thickness of rubber which is put around the running surface of the tire and which often carries small metal disks or rings, or corrugations and projections in the rubber such as are frequently seen on automobile tires. These treads are made from the thin strips of rubber gum which were first described as coming from the calender presses. They are laid together in layers while still unvulcanized, and by means of special molds they have the metallic parts incorporated in them, or the small rubber projections, corrugations and ridges are raised by means of a mold while this tread is being semi-vulcanized in a manner similar to the first process of vulcanization of the main tire, as described and illustrated in Fig. 6.

PUTTING ON THE TREAD.

In order to apply the semi-vulcanized treads to the semi-vulcanized tire a layer of rubber cement is applied to the outside of the semi-vulcanized tire, this cement being largely unvulcanized rubber in its make-up. The tread is then laid on the outside and bound to the tire by means of strips of cloth. It should be said first, however, that the cast-iron core which was in the casing of the tire during the process of vulcanizing in the hydraulic press is removed. Its place is taken in the tire casing by what is known as the air bag, which in reality is an inner tube which will hold air under pressure. This wind bag holds the tire stiff and yet somewhat flexible, while around the circumference there is applied the strip of semi-vulcanized rubber forming the tread.

BANDAGING BY MACHINERY.

Fig. 7 shows the machine which is used to bind the strip of cloth around the tire casing which contains in its interior the wind bag and around its circumference the tread which it is desired to cement and vulcanize to the main tire. The machine shown in Fig. 7, it will be seen, consists essentially of a gear wheel without any spokes or hub, it being carried and guided on its circumference by means of rollers in the frame of the machine. This spokeless gear wheel carries on its rim a wheel about 8 inches in diameter which has the cloth strips wound upon it not greatly unlike the long rolls of bandage used in a hospital, although, of course, it is not sticky. This bandage material is, however, wet when it is applied, and its application is accomplished by the rotation of the spokeless gear wheel carrying the reel round and round through the circular tire and at the same time, by means of vertical rollers which guide the tire, the latter is rotated on what would be the axis of the automobile wheel were it in place. In this way the cloth bandage is tightly laid on in a very wet condition.

The next step is to take this bandaged tire with its wind bag and tread to another steam tank where the vulcanization is completed and the tire and tread are made practically into one piece. The action of the heat, of course, expands the air in the wind bag, and as all the stretch has been taken out of the wet bandage cloth, the expansion of the air in the wind bag puts a very heavy pressure on the rubber of the casing and tends strongly to knit the parts together; that is, to make one piece out of the main tire and its tread.

Fig. 8.—MAKING THE INNER TUBES ENDLESS.

It should have been said that during the first process of vulcanization in the cast-iron mold, shown in Fig. 6, the various letters, usually of a raised character, which appear on the side of a new automobile tire, are formed; their forming is, of course, due simply to the tendency of the rubber to expand into the spaces cut for the letters in the mold itself. These letters, and in fact any marks which may be put on the mold, come out in a very sharp, clear manner characteristic of molded rubber.

THE INNER TUBES.

This, then, practically describes the making of the outer casing of automobile tires. The inner tubes are very simply made and their production is at present almost entirely hand work. The rubber gum coming from the calender presses without fabric is cut into the proper width and the edges scarfed or chamfered. These edges are then overlapped upon each other and raw or unvulcanized rubber has a strong tendency to stick together; in fact, forming one piece of material when pressed tightly together. This pressing is done

* The American Machinist.

Fig. 6.—THE VULCANIZING PRESS AND MOLDS.

Fig. 7.—THE "BANDAGING" MACHINE.

by hand, a stick of lath being inside of the folded strip of rubber upon which to press the seam of the tube.

In this form, of course, the inner tube is a straight piece having two ends somewhat like a short length of thin rubber hose. In this condition it is slipped over long metal tubes or forms, and in order to facilitate sliding it over the tubes compressed air is applied to one end of the rubber tubing which tends, of course, to expand the latter and allows it to slip over the metal vulcanizing form or tube very easily. These long forms are then wrapped with cotton bandage cloth and put into vulcanizing tanks where, by the application of heat by means of steam, the sulphur is again combined with the rubber gum, forming the well-known vulcanized rubber inner tube which is, however, still in the straight shape.

In order to make the tube endless a very ingenious device is used. Fig. 8 shows that the tubes have slipped over one of their ends a metallic sleeve. This sleeve is really double, and in the space between its inner and outer walls another sleeve fits very neatly. The rubber of the inner tube is folded down over the end of one of these short sections of metal tube, the surface of the rubber being treated with curing acid to make it raw and easily cemented. Next, the other section of tube is slipped down into the first section, and by the application of compressed air the two sections are practically shot apart, causing the turned-back section of the rubber tubing to slide over the other end and lie flat upon it. By the application of rubber bands around the outside of the joined portion sufficient pressure is brought upon the parts to cause them to stick together. The metallic tubes are removed from the now endless rubber tube by sliding the rubber out through a groove which goes down one side of each one of the metal tubes.

A WATER BALLAST MOTOR ROLLER.

A NEW ENGLISH INVENTION.

BY FRANK C. PERKINS.

The accompanying illustration shows the construction and method of operation of a novel motor roller provided with water ballast as constructed at Petersburg, England, and utilized for rolling race courses and training grounds, as at the jockey club at Newmarket. It is also employed at parks, golf links, and cricket grounds in Great Britain, as well as for road making with granite, tarmacadam, and asphalt.

This English water ballast motor roller is provided with a double-cylinder engine of 14-horse-power capacity and a kerosene carbureter. The motor is easily started with a few drops of gasoline. It is provided with a low-tension magneto, and also battery and coil in addition for ignition. The roller when loaded with water weighs about six tons, and is largely used in India as well as by some of the other colonial governments, also on several race courses in Japan.

In addition to the water circulating tank, a smaller tank is provided for carrying water to keep the surface of the front and back rollers wet when rolling tar macadam, so that this material or asphalt will not stick to the rollers. Water pipes are fitted to the car to sprinkle each of the rollers. It is stated that this arrangement has been found to work very satisfactorily, and to give excellent results for street work. The roller is 3 feet in diameter and 4½ feet wide, and weighs about 4 tons, and is provided with gearing giving two speeds. When running on the slow speed, it is claimed it will climb a hill with a gradient of 1 in 7. As to efficiency and economy of operation, it is maintained that the engine consumes on an average from 1/3 to 1/2 gallon of fuel per hour.

AN ENGLISH WATER BALLAST MOTOR ROLLER.

THE PRESERVATION OF ROADS.

TAR AS APPLIED TO SURFACE TREATMENT.

BY HERVEY J. SKINNER.

The problem of preserving the surface of roads and highways and the prevention of dust has been given attention by highway engineers for many years, but not until the year 1905 was the question seriously considered in the United States. The increasing use of automobiles and motor vehicles about this time introduced a new condition to be considered in the building and preservation of roads. Reports from various parts of the United States, England, France and wherever the use of motor vehicles had become common showed that the automobile was exerting an extremely destructive effect upon road surfaces.

The macadam road has especially been subjected to this destructive action since it is the form of construction most commonly adopted for modern thoroughfares. The binder or fine material upon the surface of the road is removed by the constant passage of automobiles, thus exposing the larger stones, which become loose and which are either left on the surface or in windrows along the sides of the road. The roughened surface presents greater resistance to traction and allows water to percolate to the foundation of the road, thereby seriously injuring the whole structure.

Up to this time the macadam form of construction had been very satisfactory for the character of traffic for which it was designed, namely, that of iron-tired horse vehicles. In a perfectly constructed macadam road, the rock used is so adapted to the kind and amount of traffic that the fine material worn off from the rock replaces that which is removed by atmospheric agencies. Under ordinary conditions it has been possible to maintain a hard and smooth surface at a moderate expense.

The advent of the automobile has changed very materially the character of the traffic. The action of the rubber tires is very different from that of iron tires, and practically no dust is worn off to replace that removed by ordinary wear. The great tractive force or shear exerted by the driving wheels of motor vehicles is the main cause of this injurious effect. It has been demonstrated by a series of experiments in which separate speedometers were connected to the front and rear wheels of automobiles that there is a very appreciable amount of slipping of the driving wheels on the surface of the road. This slipping effect throws into the air large quantities of the fine surface material, which is caught by the air currents generated by the car body and subsequently removed from the road by the wind.

Aside from the disintegrating action on the road, the dust raised by automobiles is a menace to health and a source of great discomfort to those living near much-traveled highways, especially in residential sections. Another consideration of importance is the damage to property, and instances are recorded where country estates have been disposed of far below their value, and farms and orchards abandoned owing to the dust nuisance.

The increasing number of automobiles each year emphasizes their importance as a factor to be taken into consideration, and consequently highway engineers have given careful study to the necessity of making a change in the present practice of road construction, as well as evolving some method of preserving the surface of the enormous mileage of roads already built.

The increased cost of maintenance resulting from these changed conditions has resulted in a search for some method of surfacing other than that commonly used on macadam roads. Various materials have been proposed and used, some of which are temporary in their nature and are simply intended as dust preventives. Others are more permanent in character and are advantageous in actually binding the surface of the road together, thus becoming an integral part of the structure. Of this latter class, crude oil and tar are the most important, and numerous preparations of these materials have been used with varying degree of success.

Coal tar has been employed in road building for many years. Tar macadam roadways were constructed in Nottingham, England, as early as the year 1840, although under rather crude conditions. Coal-tar pavements have been tried in various parts of the United States, but as a rule the results have not been satisfactory, asphalt being found superior as a paving material. In more recent years, tar macadam roads have been quite successful, and this form of construction is now used to a considerable extent.

* Read before the American Gas Institute.

The application of tar to the surface of a completed macadam road, while comparatively new in this country, was tried in France about forty years ago. The results were rather unsatisfactory, but the practice has been carried on to some extent at intervals since that time, especially in Italy and France.

In the United States the first experiment which attracted the attention of road engineers was in the summer of 1905, when a series of careful experiments were made at Jackson, Tennessee, by the United States Office of Public Roads in co-operation with the city engineer of Jackson, to determine the value of coal tar in the treatment of broken-stone roads. The widespread interest created by these experiments led to similar ones in various parts of the country, particularly in Massachusetts, Rhode Island, New York, New Jersey and Pennsylvania.

The variation in the methods of application and the lack of attention to the quality of the tar and the condition of the road have led to a difference of opinion as to the real value of coal tar in surface treatment.

The methods of applying the tar have varied considerably, but perhaps the one more generally used, especially in the earlier experiments, is to remove the dust and all loose particles by thoroughly sweeping the surface of the road and then applying the tar from an open kettle mounted on wheels and fitted with a portable fire box. The tar is brushed over and into the surface with stiff brooms such as are ordinarily used for street work. The kettle is kept in advance of the workmen, and by using two kettles and heating one while the other is in use the process is made continuous. After allowing the tar to soak into the surface for at least ten hours, it is covered with a layer of sand or fine stone screenings. When several hours have elapsed, the road is completed by rolling with an ordinary steam road roller.

In some places, and particularly in Europe, mechanical means have been employed for applying tar. Some years ago, the Road Improvement Association held in England a competitive trial in which many of the machines were fitted with ingenious devices. Nearly all of them provided for heating the tar and applying it under pressure by means of compressed air. Some of them were designed for carrying on the whole operation with one passage of the vehicle. The dust and loose particles were first removed by suction and drawn up into a receiver. The tar was then applied by compressed air and spread over the surface of the road by means of automatic brushes. The fine material previously removed was again distributed over the surface and rolled by the steam-heated wheels of the machine. Some of these machines were drawn by horses, and others, the larger ones especially, were self-propelled.

The method most commonly used at the present time is a compromise between strictly surface application and tar macadam construction and is known as the penetration method. In this method the surface of the road is broken up by means of a scarifier, new material added to fill ruts or other depressions, and the road reshaped. After a slight rolling without the addition of water, the tar is applied and allowed to stand as in the previous method. A dressing of fine material is then spread over the surface and the road well rolled, with the result that a surface is formed in which all of the spaces between the hard stone are filled with a minimum amount of tar. A road treated in this manner is similar to one built by the tar macadam process, in which the stone and tar are mixed before being laid.

Many of the trials which have been made with tar as a surfacing material have failed because of a lack of appreciation of a number of important details. The structure of the road, its condition at the time of treatment, the traffic to which it is subjected, the character and amount of tar used, are all important factors which are necessary for successful results.

The structure of macadam roads varies according as each engineer has deviated from the original method of macadam construction to meet his own ideas. As a rule, however, the formation of the road is much the same and is of minor importance in comparison with the actual condition of the surface at the time the tar is applied. The road should be dry and as free from moisture as possible, since water and tar are not miscible in any sense, and if the tar is applied to a wet road, the latter is, so to speak, tar proof, and proper penetration is impossible. In such a case, peeling of the surface is very liable to result, owing to the tendency of the tar to remain on the surface as a crust. It is equally important that the road surface should contain as little dust or loose material as possible, as the latter will absorb the tar instead of allowing the tar to be absorbed by the road. This again results in the formation of a crust, which under certain conditions will peel off, leaving the exposed surface of the road comparatively free from tar.

The kind and amount of traffic to which different roads are subjected is very variable, and in cases where the traffic is particularly heavy or excessive, ruts and hollows are sure to exist. These irregularities in the surface make even rolling impossible, and unless repaired previous to tarring water will collect in them and soon exert a detrimental effect upon the tarred surface. In many instances traffic has been allowed on the road too soon after treatment, and this alone has been the cause of a number of failures.

The character of the tar is of almost equal importance as the condition of the road. Tars vary widely in composition even when produced by the same process. The character of the coal used, the method of carbonization and the temperature of distillation all have a decided influence on the composition of the tar. The value of coal tar in the surface treatment of roads depends almost entirely upon the binding power of its heavy bitumens. Besides these bitumens there are present other substances such as water, ammoniacal liquor, oily constituents including the light oils and the creosote or "dead" oil, naphthalene, anthracene and similar compounds, and free carbon, the proportion of which varies according to the manner in which the distillation process has been carried out.

The presence of water in coal tar has a similar effect as moisture in the road. If a tar containing water is applied to a dry road, the latter absorbs the water more readily than the tar, producing the tar-proof effect to which reference has already been made. Difficulty is also experienced in handling tar containing an appreciable amount of water since the water causes foaming, and if the vessel is heated by direct fire the danger of the tar going over the side of the vessel and taking fire is great.

Ammonia is another undesirable constituent, it being alkaline in nature and having a tendency to form with the oil constituents soluble compounds which are easily washed out by the action of the rain.

Napthalene and anthracene, while they exert no particularly harmful effect as in the cases of water and ammonia, have no binding power, and their pressure simply reduces the amount of bitumens which may be present.

Free carbon, like naphthalene, has no detrimental effect, but, on the other hand, it is a useless constituent so far as road treatment is concerned, and its presence reduces the binding power and waterproofing effect since it possesses none of these qualities itself.

The oily constituents of the tar are valuable to some extent since they act as diluents. The light oils are more or less volatile and are probably evaporated soon after the tar is applied to the road, but their presence makes the tar thinner and consequently renders their application easier. The creosote oils are also of some advantage, as it is claimed they add life to the tar and prevent its becoming too brittle.

The amount of tar is another important detail, and if more is applied than the road can properly absorb it will remain on the surface and be taken up by the top dressing with the resulting formation of a crust. Another objection to an excessive amount of tar is that it has a tendency to become sticky in warm weather and slimy in wet weather.

Sand or fine stone screenings have been used as a top dressing in the majority of the trials with coal tar, although occasionally the fine material removed from the road previous to tarring has been used. Stone screenings are probably the best material to use on a macadam road since they furnish a dressing of the same material as the road itself.

A comparison of coal tar with other road binders and dust preventives is somewhat difficult in the absence of really comparative experiments. Some few trials have been made in which different materials were used on the same stretch of road, but in most cases these experiments using such materials have been on different sections of roadways, and consequently the results are not truly comparable.

Another cause for lack of comparative data lies in the great diversity of materials which have been used. As we have seen, the efficiency of a dust preventive is in proportion to its binding power, and therefore a comparison of only those materials of approximately the same binding power is justifiable. The various dust preventives really form a series from water, which has no binding power, up to coal tar and the heavy asphaltic oils, which have the maximum binding power of any of the materials yet proposed.

Water, salt solutions and light oil emulsions are of the nature of temporary binders and are not to be compared with the more permanent ones such as coal tar and oils having an asphalt base.

The use of oil has been confined largely to the United States, and by far the greater portion of the work has been done in the West, owing to the proximity of the oil fields which supply oils with an asphalt base. In the eastern portion of the United States the cost of transportation has been so great that comparatively little experimenting has been done with oil. Tar has been used quite extensively abroad, especially in England and France. In the United States, its use has been confined very largely to the eastern and northern States, although the park authorities of the larger cities have used tar to quite an extent.

Experiments have pretty clearly demonstrated that tar is not adapted for the treatment of gravel or soft earth roads owing to the fact that it does not amalgamate sufficiently well with these materials to bind them together. For roads of this class, therefore, oil has been more successful than tar. The use of tar has been and must be confined almost entirely to macadam or broken-stone roads, and for roads of this nature it is probably more suitable than oil.

Oil, as a rule, has greater power of penetration than tar, but its value is dependent in a large measure on its asphalt base, and before its maximum binding power is reached the more volatile constituents of the oil must be allowed to evaporate. This evaporation is a slow process, and until it is complete the disagreeable odor of the crude oil will be apparent and more or less objectionable. The use of oil has also received considerable criticism owing to the damaging effect which it has upon clothes and the paint and varnish of vehicles, especially in damp weather, when a greasy, disagreeable mud is formed.

Tar, on the other hand, solidifies quite completely as soon as it is cold and does not depend except to a small degree on the gradual evaporation of its volatile constituents for its hardening. It is comparatively free from the objection of being picked up and thrown by the wheels of vehicles, and although it has a decided odor which lasts for a short time after application, this is not particularly objectionable and to most people is much less offensive than that of crude oil. An objection is sometimes raised to the use of tar on account of a fine black dust which wears off of the tarred surface. It is true that such a dust is formed, but the amount is insignificant in comparison with the dust which would have formed if the road had been untreated.

It is claimed that coal tar has a decided antiseptic value, but how much importance can be attached to this feature is questionable. It is reported that an investigation was carried on in France to determine the number of germs present in the atmosphere over a tarred and an untarred road in the same neighborhood, and the number over the latter was found to be considerably in excess of those over the tar-treated section. Crude oil also possesses a similar antiseptic property, but to a very much less degree.

A properly tarred road is similar to an asphalt pavement, although of a more resilient character. The stone is all bonded together by the tar into a smooth, firm surface which can be swept and washed in much the same manner as an asphalt pavement.

The principal agencies which cause deterioration of tarred or oiled surfaces are heavy rain, frost, and the decaying organic matter which accumulates on the surface of the road. So far as can be determined, one kind of road withstands the action of these agencies as well as the other.

Water gas tar is used in connection with coal tar, but not to any great extent by itself. It has a greater power of penetration and less of it is required, but it is not so lasting in character. It is really in a class by itself and occupies an intermediate position between the temporary and the permanent binders. In some cases where a limited amount of money is available or where for climatic reasons it is advisable to treat the road with the idea of its lasting only through one season, water gas tar should prove a valuable dust layer, and any extension of its use will undoubtedly be in this direction.

The value of coal tar in the preservation of macadam roads and as a dust preventive is still unsettled. It is certain, however, that in the majority of cases the life of a treated road has been materially lengthened, and by applying tar the complete rebuilding of many roads at an enormous expense has been avoided.

One great drawback in the standardization of tar treatment is the impossibility of securing a uniform supply of coal tar. Coal tar is purely a by-product, and the processes by which it is derived are never run with reference to the quality of tar produced, but solely to obtain maximum yields of gas or coke, as the case may be.

The impossibility, therefore, of manufacturing tar to meet definite requirements makes it necessary to utilize the supply available, but in so doing a certain amount of selection can be exercised and changes made whereby some degree of uniformity is obtained. Some attempts have been made to control the quality of the tar, but with rather unsatisfactory results. The manufacture of special coal-tar preparations was intended to provide a greater uniformity, but many of these are, in the opinion of those who have used them, very variable, and the success attending their use is not in proportion to the extra price paid for them.

Strictly surface treatment of an already existing road, even under the best conditions, can only be regarded as a temporary expedient, and its use will probably extend only in cases where for financial or other reasons the rebuilding of the road is not justified.

Partial reconstruction of the road whereby the sur-

face is loosened, reshaped and the tar applied before the rolling is done is undoubtedly a method of considerable value and one which will find more general application in the future. Many highway engineers have predicted an entire change in the methods of road construction, but it is difficult to believe that the macadam method, which has been so universally and so successfully used for a long time, can be eliminated. It is more probable that some modification of the macadam form of construction will be adopted, in which event the tar macadam method is sure to be one of the first to receive serious consideration.

CHARTING THE HEAVENS.

THE MEETING OF THE PERMANENT INTERNATIONAL COMMISSION.

BY JULES BAILLAND.

THE sixth meeting of the Permanent International Commission for Charting the Heavens has just been held at the observatory of Paris. The work of the commission is very important, and deserves detailed explanation.

In 1887 an International Congress decided to make a new photographic map of the heavens by the co-operation of seventeen observatories, situated in various countries and using instruments of the type of the astrophotographic equatorial telescope with which the brothers Henry had obtained some admirable photographs at the observatory of Paris. This immense work, which will give with precision the positions and magnitudes of more than 20,000,000 stars, will certainly furnish, when completed, an invaluable foundation for astronomical researches of all kinds. The accomplishment of the task appeared, at first, to require not more than fifteen years, but twenty years have passed and the end is not in sight. This delay was unavoidable and it has proved fertile, for the introduction of a new method brings to light new and unexpected problems and the work of the commission has influenced almost every branch of astronomy.

The original project called for the construction of an atlas showing all stars down to the 14th magnitude; that is to say, all the stars that can be seen with a telescope of 24 inches aperture. But, while existing atlases merely enable the astronomer to find his position among the stars, the new atlas will be a document of extreme accuracy, as the purely photographic method of reproduction necessarily records with precision, not only the positions, but also the relative sizes of the stellar images, although these are only a few thousandths of an inch in diameter.

At the 1896 meeting of the commission it was decided to adopt the heliogravure process, which has the very great advantage of preserving for the future, in the copper plate from which the maps are printed, an almost indestructible document, but which has the inconvenience of introducing a large number of false images. In order to distinguish the true images from the false it is necessary to expose each negative three times, thus producing for each star three images, arranged to form an equilateral triangle. In this way the true images can be easily recognized, but the time of exposure is tripled. Consequently, the photographic work of the commission is still far from completion. The French observatories have accomplished about one-third of the task assigned to them, and so have the observatories of San Fernando in Spain, and Tacubaya in Mexico. The heliogravure plates of their work are being made in France. The English observatories and the observatory of Helsingfors in Finland made their negatives by single exposures, and have finished their work. The plates made at Greenwich have already been printed, but these gelatino-bromide prints on paper, although very beautiful, are assuredly far less permanent, and consequently less valuable than the copper heliogravure plates. Some of the observatories have scarcely commenced their task, and a few have given up the work.

To the construction of this atlas was added in 1899 the work of establishing a catalogue of the exact positions of all stars down to the 11th magnitude. The short exposure negatives necessary for this purpose could be obtained rapidly in most observatories, and the practical difficulty, which is due wholly to the enormous number of measurements and calculations, becomes reduced to a question of money. There are, however, some theoretical difficulties. A star map represents a central projection of the celestial sphere upon a tangent plane. The rectangular measurements made in this plane are not directly expressed in the spherical co-ordinates, right ascension and declination. It was necessary, therefore, to establish formulas of reduction, as simple as possible. This auxiliary work necessitates a preliminary knowledge of the spherical co-ordinates, obtained by meridian instruments, of a number of stars, called stars of reference.

Unfortunately, good meridian positions are not known for all the stars which it was desired to use, and one of the first tasks of several of the observatories was the establishment of supplementary meridian catalogues, a task which certainly did not enter into the original project. The plan of work which has been adopted, however, allows the number of reference stars to be diminished. The parts of the sky photographed on the different plates overlap, so that the same co-ordinates ought to be obtained for any star found on two plates, no matter which plate is used. This fact makes it possible to use, in the determination of the elements of a plate, the reference stars of adjoining plates. This work of adjustment has not been begun, nor is the best method of accomplishing it yet decided upon.

In addition to the positions of stars, the catalogue gives their magnitudes. Here the problem to be solved is three-fold. It is required first to classify the stars of each plate according to magnitude; then to make a photometric adjustment of the different plates, so that their data shall be comparable to each other, notwithstanding the apparent differences caused by differences in the sensitiveness of the plates and the transparency of the air; and, finally, to fix the units in which the results shall be expressed. It is not difficult to classify the star images of a plate, for their diameters increase in proportion to the magnitudes of the stars, but in regard to securing uniformity among the plates and selecting the unit of magnitude there was no agreement until the last meeting of the commission. Many observers had partly solved the problem by comparing the magnitudes of certain stars, determined by visual photometric processes, with their magnitudes as estimated from the plates. But as these two results are furnished by different rays of the spectrum, they are not strictly comparable.

The advantages which observations of the planet Eros, made during the winter of 1900, offered for the determination of the solar parallax, and the great precision attributed to the photographic method, caused a large proportion of the observatories, at the suggestion of Loewy, to interrupt their work on the chart of the heavens for a time in order to make and reduce observations of Eros. The discussion of the enormous mass of data thus accumulated has been concluded by Hinks of the observatory of Cambridge. This discussion, independently of its intrinsic importance, has been of great benefit in the work of the photographic star catalogue, by exposing numerous sources of error arising from defects of lenses and methods of reduction, and errors in the positions of reference stars.

In the meeting just held, the commission discussed all the questions at issue and prepared for observations of Eros during its opposition in 1931. Of particular interest was the announcement of the value found by Hinks for the solar parallax, 8.806 sec., with a probable error of two or three millionths of a second. The value previously accepted was 8.80 sec.

Some important resolutions were passed. The zones of the southern celestial hemisphere, work on which has not yet been commenced, were distributed among three observatories. Heliogravure plates have been made hitherto only for the French observatories and those of San Fernando and Tacubaya. The royal observatory of Belgium will follow their example in making the map of a region, of which the catalogue will be made by the observatory of Potsdam. There remain many regions which have been abandoned by the observatories to which they were assigned, because of lack of time, money, or facilities for heliogravure work. The French astronomers have had the great satisfaction of seeing confided to France the reproduction of the negatives of all the hitherto uncompleted zones traversed by the ecliptic; thus they will bequeath to future astronomers the image, engraved on copper, of a full half of the sky, constituting its most interesting portion, a monument worthy of their compatriots, by whose labors the visual map of the zodiac was made in the nineteenth century.

The attempt to make the magnitudes of stars in the new catalogue agree with the magnitudes in the visual catalogues has been abandoned, and as types of magnitude a number of circumpolar stars which have been photographed by the observatory of Harvard College have been chosen. Finally, in order to improve the positions of the stars of reference, it has been decided to make a new and complete system of fundamental meridian catalogues. This is an enterprise of the greatest importance and difficulty, which is made possible only by the progress accomplished in the last twenty years in the construction of meridian instruments. The task should be completed within a comparatively short period, owing to the collaboration and agreement of a large number of observatories and astronomers skilled in this special work. The permanent commission of the chart of the heavens, which had already extended its function to include the observations of Eros, has now extended them much further. In fact there is hardly a branch of astronomy, with the exception of spectroscopy, which will not be affected by the change in the positions and magnitudes of fundamental stars. Hence the commission, as one of its eminent members remarked, is reorganizing astronomy.—Jules Baillaud, adjunct astronomer at the observatory of Paris, in Revue des Sciences.

ANTS AND THEIR SLAVE GUESTS.

ON some of the fine warm days that burst upon us in the early autumn, large swarms of winged ants issue forth and fill the air in certain localities, swarming over the bushes and trees, and even the grass in prodigious numbers.

These extraordinary excursions are expensive to life, for it would not be an exaggeration to say that the majority of these hordes perish, many from their enemies the insect-eating birds, and many more from cold and exposure during the damp autumnal evenings. These winged ants that swarm thus are composed of the two higher grades of caste in the communities, the males and females, some of whom are destined to be queens; the workers, which are the mainstay of the community, are modified females, and are wingless, and consequently take no part in these flittings. The main purpose of this autumnal migration from the nest appears to be for mating, and the females that survive become the founders of fresh colonies, or find their way into existing nests, which they strengthen the ensuing season by introducing fresh stock.

There are some species of ants that keep their colonies going by kidnapping at this time of the year the workers from other nests, and compelling them to work for the benefit of their community. These slave raids are made chiefly by the large Amazon ant, and the nests raided are generally those of the familiar brown garden ant. They time their raids to a nicety, for they make their attack just about the time the males and females are emerging from the pupa stage, but they do not want these; their object is to carry off the pupa of a worker, the others being left to perpetuate the species. These red marauders carry out their attacks in a very workmanlike manner, for an advance of scouts, who hurry back to report, always precedes the storming of the castle. A small vanguard, consisting of a few individuals, makes the preliminary assault; its object seems to be to engage the guardians of the castle, who quickly raise the alarm, and the garden ants pour out from the labyrinths of their nest in thousands. This is the signal for the main attack, and the red ants rush in in a body, and, overpowering the defenders, make their way into the inner recesses, to emerge again, each one with a worker pupa in its jaws, and an orderly retreat is made back to their own quarters, where the pupæ are deposited, and tended with the greatest care. These kidnapped workers finally emerge into a state of utter slavery, for they have to perform the whole work of the red ants' nest; they build the passages, do the repairs, undertake the care of the pupæ, and work apparently just as hard and just as willingly for this more aggressive species as if they had been working for their own.

This employment of other species to serve their own ends is quite common among all ants, for it is a well-known fact that they keep cattle, in the shape of the aphides, which they tend very carefully, drawing a supply of milky fluid from them. The working ants, whether of their own or of another species, are always in a condition of slavery; guests are frequently entertained, certain beetles being always found in their nests, where, apparently, they serve no useful purpose, but are fed by their hosts with a liberal hospitality. The large horse ant always allows a smaller species

to occupy its home, and there is a curious lobster-like creature, commonly known as the tassel-tail, that always maintains itself in the nest of a certain species of ant; it appears to reward its hosts frequently by stealing food from out of their mouths, and then beating a hasty retreat. This last species of ant (Lasius) seems to be remarkable for its kindness to uninvited guests, for it actually treats with a remarkable toleration certain mites, which they carry about on their bodies, feeding them and tending them in a most careful manner, though for what purpose no one can tell.

ENGINEERING NOTES.

On board ship the benefits accruing from forced draft, states the Vulcan, are more pronounced than on land. The height of the funnel of a steamer is restricted, and natural draft comparable with land practice can only be obtained with a high temperature. With mechanical draft the intensity of the fire is independent of chimney temperature, and the heat of the waste gases may be used to heat the feed-water or the supply of air to the furnace. Artificial draft is independent of atmospheric temperature, which not infrequently causes inconvenience on board ship in tropical climates if the draft depends on the chimney.

The new Pennsylvania terminal station in New York is rapidly approaching completion, and the last piece of stone in the exterior finish of the station was recently put in place. The dimensions of this work are unusually large. The exterior walls are nearly half a mile long, and they contain 490,000 cubic feet of granite. Adding to this 60,000 cubic feet of stone used inside the concourse gives a total of 550,000 cubic feet of granite, weighing 47,000 tons, which required 1,140 freight cars to transport it from the quarries at Milford, Mass. Into the construction of the building there have also entered 27,000 tons of steel and 15,000,000 bricks, weighing 48,000 tons.

During the past eight or ten years a good many examples of concrete-sheathed timber pile construction have been built by the State Harbor Commissioners at San Francisco, the object being to obviate the rapid destruction of unprotected timber by the teredo, which is very active in the Bay of San Francisco. Ordinary wooden piles driven to secure the requisite bearing, were provided with an outer casing of concrete formed in cylindrical molds placed over the piles after driving. From a recent article by Mr. John G. Little, in the Engineering News, it appears that the present condition of piers built on this type of substructure is far from satisfactory, and that in consequence, reinforced concrete cylinder piers are being adopted in the important scheme of harbor improvements now in progress.

In the first seven months of 1909 the railways of the United States ordered 53,900 freight cars, compared with 8,040 and 105,620 during the same period in 1908 and 1907 respectively. The locomotive orders at the same time amounted to 1,009 in 1909, 386 in 1908, and 2,685 in 1907. These figures show that while the railway equipment business is far ahead of last year it is still nearly 50 per cent behind that of 1907 as regards freight cars, and 60 per cent behind as regards locomotives. The difference between 1909 and 1907 is due to the fact that while in 1907 orders were placed in good volume from the first of the year, in 1909 the roads only ordered equipment spasmodically until June, when the genuine rush to buy began, 28,985 freight cars out of a total of 53,990 having been purchased in June and July of the latter year.

The Bulgarian government recently had built by a German firm a new type of portable generator, using a gasoline motor coupled direct to a three-phase alternator. It is designed to furnish current for operating motor-driven pumps in the mineral springs which the government controls. The pumps are placed at the bottom of shafts and the whole pumping group is lowered into the shaft on an iron frame. For this purpose a portable outfit for the current supply is necessary, hence the design of the present group. It consists of a four-wheel wagon truck upon which is mounted the motor-generator set. There is used a Deutz petrol engine of the upright four-cylinder type, of the 40-horse-power size. The speed is kept very close by a governor. On the truck is placed a 400-gallon tank with the cooling water. Russian oil is used here, and the consumption is 420 grammes per horse-power hour. The alternator runs at 500 R.P.M. and furnishes 30 kilowatts at 500 volts, with an exciter mounted on the end of the shaft. On a rectangular frame of channel iron is placed the pump set, using a three-phase motor of the squirrel cage type of 20-horse-power size, running at 1,450 R.P.M., and it is made waterproof. A hand-operated cable drum lets down the entire frame to the bottom of the shaft or to any required depth. Current is taken to the motor by a well insulated cable. In this way the mineral water is pumped out with a high rate of delivery.

ELECTRICAL NOTES.

A new telegraph cable has recently been laid right across the Forth Bridge. The cable, which was laid by the post office, and is their property, has taken the place of the former one, which was found to be unsatisfactory. A train of six wagons was employed to convey the cable, and this moved slowly across the bridge while the men laid the cable down on the footpath on the up line side of the bridge.

In connection with the design of certain special towers in wireless telegraphy, in which numerous guys, together with the tower, act as an aerial capacity, the necessity arose of finding a quick method of determining the sags and tensions in the guys at different temperatures. The author of an article in the Electrical World obtains a simple cubic equation from which the sag can be readily determined. A numerical example is worked out completely to illustrate the method. It is shown how the wind pressure can be taken into account, and useful practical diagrams showing how the wind pressure varies with the velocity of the wind are given. The effect of a coating of ice on the wires is also discussed. This coating is usually elliptical in section.

Considerable success is found in operating the storage battery cars on the Prussian railroads. There are now a number of such lines working regularly, and among these are the Mainz-Oppenheim and the Limberg-Camberg. On the latter railroad there are some points of interest in the operation of the cars. The speed is regulated by different couplings of the battery cells, and there are used 176 cells giving 340 volts. The cells are mounted in eight groups, which furnish 42 volts each. On the car are four 50-horse-power motors, and these are permanently coupled in parallel, using a controller of 8 points. For grouping the cells there is used a battery switch, which is operated by a small electric motor. This latter is in turn handled by the motorman's switch. On the Limberg line the battery cars weigh 60 tons in all, comprising 10 tons for the electric apparatus and 17 tons for the storage batteries.

A new form of primary battery has been placed on the market in Germany within a recent period. It is known as the nitroine battery, and is claimed to work for a long time and to be specially applicable for use with metallic filament lamps. It uses a positive electrode of carbon which is hollow and thus serves as the porous matter. The electrode is filled with a depolarizing liquid of special composition which is a mixture of sulphuric and nitric acids, together with oxidizing agents not specified. Outside the carbon there is a zinc electrode placed in a solution of sulphate of zinc. For one kilowatt-hour supply, the consumption of zinc is said to be but 1.8 pounds, and in the case of metallic filament lamps we obtain one candle power-hour for 0.7 cent. However, in practice the battery is not used directly on the lamps, but it is found preferable to charge a storage battery with it and then use the latter for running the lamps.

According to the Electrical World, the consulting engineer for the electrification work of the Great Northern Railway tunnel through the Cascade Mountains, U. S. A., has concluded exhaustive tests of the electrified section, which is now in successful operation, heavy freight trains being hauled a distance of about four miles from the yard at one end of the tunnel to the yard at the other portal. Four three-phase locomotives are at present in use, each of which weighs 115 tons; and the recent tests show that they are fully capable of performing more work than required by the specifications. When very heavy freight trains are hauled through the tunnel three of the locomotives are used. In addition to the trains a heavy steam locomotive is at present pushed through in order to take the train at the end of the electric zone. So far as the brief operation of this short stretch of electric road has shown, it is an entire success. Upon the ultimate success of this piece of track depends the electrification of about sixty miles of the Great Northern through the entire Cascade Range.

Some time ago Mr. W. B. Woodhouse referred to the question of supplying electricity to power users from small central stations in the following terms: Practice has shown that the small generating station cannot produce electricity at a price sufficiently low to enable it to be supplied to power users at a competitive price. A station of 1,000 kilowatts, for example, cannot hope to supply a power user requiring 300 kilowatts as cheaply as the power user can generate for himself; this for several reasons. First, the capital cost of the generating plant will be practically the same per kilowatt, while the public supply is burdened with an additional cost for mains; secondly, the owner of an isolated power plant will usually erect a smaller proportion of stand-by machinery, setting the increased risk of shut-down against the reduced capital charges; thirdly, the public supply stations must run continuously, often at very inefficient loads, whereas the isolated plant, a mill engine for instance, is only run during certain definite hours, so that the "working load factor" is greater and the works cost less in the case of the latter. Apart from this, one finds the owners of isolated power plants very frequently do not include any allowance for rent, management charges, etc., in estimating their power costs, so that the difficulty of the supply authority obtaining such a load is increased by the power user's want of appreciation of all the items making up power costs.

TRADE NOTES AND FORMULÆ.

Tallow emery is a mixture of beef or mutton tallow with emery powder of varying degrees of fineness, which is used particularly by grinders for removing the furrows in grindstones, caused by sharpening. It is prepared by melting tallow to fluidity, stirring the emery into the melted mass of fat and continuing the stirring until the mixture begins to set. By this means, a much more intimate combination is effected than where tallow and emery are mixed without first melting.

Tricostine de l'Inde (waterproof leather varnish).—100 parts of ivory black are intimately mixed into a paste with 30 parts of Japanese varnish and rectified turpentine. Then dissolve 15 parts of virgin wax in wax oil and 1 part of caoutchouc (India rubber) in oil of rosemary. Mix both solutions, stirring constantly, in the water bath, and gradually add, continuously stirring, the above paste. When the mixture is complete, pass over it, for an hour, a current of oxygen, and pass it between a set of three rollers. The tricostine is then finished. It must be kept in hermetically closed tin tubes.

Protection of Iron from Rust.—The well cleansed iron articles, according to Hess, are suspended for a very short time in a blue vitriol solution, so that a slight film of copper is formed on the surface. Shake the objects, rinsed in water, for a few minutes in a solution of hypo-sulphite of soda; they will acquire a blue-black coating of sulphide of copper, which, as is well known, is equally resistant to air and water. The black surface can easily be washed off with water, dried with rag or blotting paper and polished with a burnishing stick; it possesses a steel-blue glitter, adheres firmly to the iron, withstands treatment with the scratch brush, and affords good protection against rust.

Protection Against Rust for Iron Wire.—The wire is placed in a rotating kettle in which a temperature of 636 deg. F. (300 deg. C.) is constantly maintained; the air it at first contains is replaced by superheated steam. Then, for a time, certain hydrocarbons are allowed to work on the surface of the wire, another bath in superheated steam completing the process. By this means, a very tough skin is said to be given to the metal, which it does not readily lose, even under the hammer. The wire is then tested, to ascertain whether it has lost any of its property of conducting electricity. The cost of the process is quoted at one-fourth that of galvanizing.

Pipe Covering.—I. A coating, made up of leaves of mica, or a similar substance, having numerous air passages and of suitable thickness, is inclosed on all sides by a covering coat, consisting of a non-combustible and readily hardening binding agent, and mica or similar substance. On subsequent heating in a drying stove, this paste-like outer coating, pushing inward, in the shape of irregular projections, combines the inner protective layer inseparably and inwardly with the outer covering, so that on the outside a solid, continuous coating will be formed. II. 5 parts each infusorial earth (kieselguhr), ground glass, and chamothe powder, and 10 parts ashes are pulverized, and mixed with soda water-glass solution, into a thick paste of which several coats are applied to the surface to be protected until the layer is thick enough, possibly 6 millimeters (¼ inch). While drying, the mass is enveloped in jute strips, soaked in water-glass solution, or after drying it is coated with this adhesive and the strips rapidly applied. This mass will withstand high temperatures.

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